

STRESS AND VIBRATION CHARACTERISTICS OF A
PLANETARY ENTRY CAPSULE IN THE LAUNCH CONFIGURATION

By Gerald A. Cohen

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SUMMARY

The stress response to 10 g axial and 5 g lateral inertial loadings and the natural vibration modes of a blunt conical glass fiber sandwich capsule adapted to a boost vehicle through an aluminum conical shell were studied using Novozhilov shell and ring theory. Two modes of capsule support were considered. In one case (shell supported) the adapter shell connects to the base of the capsule shell, and in the other case (payload supported) the adapter shell connects to the payload, which is hung from the forward section of the capsule shell. Whereas the capsule base diameter was assumed to be 144 inches, for each of the launch configurations both 120 inch and 165 inch adapter base diameters were considered.

It was found that the shell supported configurations have larger capsule shell stresses but smaller adapter shell stresses than the payload supported configurations. As a result of the large kinetic energy associated with axial oscillation of the payload mass, the minimum frequencies (17.1 cps, 18.1 cps) of the shell supported configurations occur in axisymmetric modes. On the other hand, the minimum frequency (13.1 cps) of the payload supported configurations occurs in an approximately inextensional mode with two circumferential waves of the capsule shell section aft of the payload ring.

INTRODUCTION

With the advent of sophisticated computerized analysis of shell structures it has become possible to obtain the structural response of entry capsules which heretofore could be obtained only by expensive full-scale tests.. Although the capsule is designed primarily to survive the entry environment, its response in the launch environment must not be overlooked. In this study the digital computer was used to obtain the quasi-static stress response to axial and lateral inertial loadings and the free vibration modes of a potential Voyager capsule in several launch configurations, including the interaction of capsule shell, payload, and adapter shell. The stress response was obtained through the use of a digital computer program based on the forward integration method of Novozhilov's shell equations presented in Reference 1. The vibration modes were obtained through use of a second digital computer program which solves the eigenvalue problem associated with the governing differential equations

for general ring-stiffened orthotropic shells of revolution by means of the modal iteration method presented in Reference 2.

NOMENCLATURE

A	area of ring cross section
d	normal eccentricity of ring centroidal axis measured from capsule shell middle surface, positive for internal rings
E	Young's modulus
I_o , I_1	rolling and pitching mass center moments of inertia, respectively, of payload attachment
I_x , I_y , I_{xy}	centroidal moments and product of inertia of ring cross section about axial (x) and radial (y) axes
J	torsional inertia of ring cross section
M	mass of payload attachment
N	circumferential wave number
s	meridional distance (see Figure 1)
t	shell wall layer thickness
U, V, W	meridional, circumferential, and normal displacement amplitudes ($u = U \cos N\phi$, $v = V \sin N\phi$, $w = W \cos N\phi$)
u, v, w	meridional, circumferential, and normal displacements of shell wall
μ	Poisson's ratio
ρ	mass density
Σ_s , Σ_ϕ , $\Sigma_{s\phi}$	normal and shear stress amplitudes of antisymmetric stress distributions ($\sigma_s = \Sigma_s \cos \phi$, $\sigma_\phi = \Sigma_\phi \cos \phi$, $\sigma_{s\phi} = \Sigma_{s\phi} \sin \phi$)
σ_s , σ_ϕ , $\sigma_{s\phi}$	normal and shear stresses in shell wall
ϕ	circumferential angle measured from axial plane of symmetry of structural response

CAPSULE LAUNCH CONFIGURATIONS

A sketch of the launch configurations is shown in Figure 1. In each case the payload is assumed to be attached to the capsule shell through a payload ring which is rigidized by the payload, and the adapter shell is assumed clamped at its base to a rigid boost vehicle. In the Case II configurations the adapter shell is also clamped to the rigid payload. The quasi-static stress distributions obtained neglect the effect of aerodynamic surface loads on the structure shown. The only external forces are assumed to be a resultant axial force (producing a 10 g acceleration) and a resultant lateral force and moment (producing a uniform 5 g acceleration), each of which acts through the rigid base of the adapter. The vibration modes obtained represent oscillations about the unstressed state of the structure assumed to be clamped to ground at the adapter base.

In each case the glass fiber sandwich capsule shell is composed of three isotropic layers. The properties of the sandwich face layers are: $E = 2.0 \times 10^6$ psi, $\mu = 0.136$, $\rho = 0.065$ lb/in.³, $t = 0.015$ in. The sandwich core layer is 0.75 inch thick and is assumed to provide negligible rigidity in tangential directions while providing sufficient transverse shear and normal rigidity in order that the thin shell hypothesis of non-deformable normals remains valid. The total surface density of the capsule shell is 0.0125 lb/in.² (including core, bonding material and heat shield). The adapters are aluminum monocoque shells with the following properties: $E = 10.5 \times 10^6$ psi, $\mu = 0.32$, $\rho = 0.10$ lb/in.³, $t = 0.030$ in.

Although the stiffening ring at the capsule-adapter juncture of the Case I configurations was conceived to be a heterogeneous ring composed of both filamentary material and aluminum, for the purpose of analysis it is modeled as an equivalent homogeneous ring with the following properties: $E = 2.0 \times 10^6$ psi, $\mu = 0.136$, $\rho = 0.040$ lb/in.³, $A = 2.5$ in.², $I_x = 6.0$ in.⁴, $I_y = 3.0$ in.⁴, $I_{xy} = 0$, $J = 6.0$ in.⁴, and $d = 2.5$ in. The capsule shell base ring for the Case II configurations is a glass fiber tubular ring with the following properties: $E = 2.0 \times 10^6$ psi, $\mu = 0.136$, $\rho = 0.065$ lb/in.³, $A = 1.0$ in.², $I_x = I_y = 3.0$ in.⁴, $I_{xy} = 0$, $J = 6.0$ in.⁴, and $d = 2.5$ in.

The dynamical properties of the payload attachment mass (including the payload ring), which is assumed to be perfectly rigid, are: $M = 950$ lb, $I_o = 221,500$ lb-in.², $I_1 = 146,000$ lb-in.².

RESULTS

Quasi-Static Response

Case I (Shell Supported Configurations)

Figures 2 and 5 show the numerically maximum (with respect to ϕ) stress distributions for the 120 in. and 165 in. base configurations, respectively, under the combined 10 g axial and 5 g lateral inertial loadings.* These stresses are decomposed into their axisymmetric and antisymmetric components in Figures 3, 4, and 6, 7, respectively. Only the amplitudes Σ_s , Σ_ϕ , $\Sigma_{s\phi}$ of the antisymmetric stress distributions are shown in Figures 4 and 7. The adapter-capsule interfaces are at $s = 27.7$ in. and $s = 27.1$ in. whereas the payload rings are at $s = 89.3$ in. and $s = 88.7$ in. for the 120 in. and 165 in. base configurations, respectively. As might be expected, there is almost negligible variation of stress through the thickness of each face layer of the capsule shell; also, the capsule shell stress distributions are relatively insensitive to the adapter base diameter change. The maximum capsule stresses are meridional stresses occurring at the outer face of the outer glass fiber layer immediately aft of the payload ring. The maximum adapter stresses occur at the outer shell face immediately aft of the adapter-capsule interface. For the 120 in. base the maximum stress is circumferential whereas for the 165 in. base the maximum stress is meridional. These results are summarized in the following table of maximum stresses (psi).

	Capsule		Adapter	
	120 in. base	165 in. base	120 in. base	165 in. base
Axisymmetric	-5,932	-5,930	5586	-4159
Antisymmetric	-4,430	-4,430	2003	-726
Total	-10,362	-10,360	7589	-4885

* Shell wall layers are numbered in the order encountered as the wall thickness is traversed starting with the innermost layer. Tangential shell stresses for the sandwich core (layer 2) are not shown, since, in consequence of the assumption of negligible tangential core rigidity, they are negligibly small.

Case II (Payload Supported Configurations)

In the payload supported configurations the rigid payload mass effectively decouples the quasi-static response of the capsule shell from that of the adapter shell. Thus, in these cases, the capsule shell stresses are independent of the adapter base diameter. Figures 8, 11, and 14 show the maximum stress distributions for the capsule shell, the 120 in. base adapter shell, and the 165 in. base adapter shell, respectively. These stresses are decomposed into their axisymmetric and antisymmetric components in Figures 9, 10; 12, 13; and 15, 16, respectively. Only the amplitudes Σ_s , $\Sigma_{s\phi}$, $\Sigma_{s\phi}$ of the antisymmetric stress distributions are shown in Figures 10, 13, and 16. Since the meridional distance is measured from the capsule shell base for the Case II configurations, the payload ring is at $s = 61.6$ in. The maximum capsule stress is a meridional stress occurring at the outer face of the outer glass fiber layer immediately aft of the payload ring. The maximum adapter stresses are also meridional stresses occurring at the outer shell face immediately aft of the payload end of the adapter shell. These results are summarized in the following table of maximum stresses (psi).

<u>Capsule</u>	<u>Adapter</u>	
	<u>120 in. base</u>	<u>165 in. base</u>
Axisymmetric	1817	-6724
Antisymmetric	2196	-2315
Total	4013	-9039
		-8,880
		-3,209
		-12,089

Vibration Modes

Case I (Shell Supported Configurations)

Figures 17 through 27 and 28 through 38 show the displacement amplitudes U, V, W of the lowest three natural vibration modes for $N = 0$ through $N = 10$ for the 120 in. and 165 in. base configurations, respectively. The minimum frequencies of the 120 in. and 165 in. base configurations are 17.1 cps and 18.1 cps, respectively. Both of these frequencies occur for the lowest axisymmetric bending mode, in which the payload mass has a large translational kinetic energy. Except for vibrations with a large number of circumferential waves ($N \geq 8$) at relatively high frequencies, in the lowest three modes the adapter shell has relatively small amplitudes. Changing the adapter base diameter from 120 in. to 165 in. consistently increases the natural frequencies by a small amount and has a correspondingly small effect on the mode shapes. These results are summarized in the following table of natural frequencies (cps).

120 in. base

N:	0	1	2	3	4	5	6	7	8	9	10
	17.1	17.9	48.6	39.0	38.3	43.9	53.1	64.6	77.8	92.4	108.3
	65.6	36.5	79.8	76.8	78.2	84.8	96.1	111.0	128.5	147.6	162.8
	75.9*	62.7	114.5	115.6	120.8	130.4	144.3	162.1	182.6	181.1	170.0

165 in. base

18.1	18.2	48.8	39.1	38.3	43.9	53.3	65.0	78.3	92.9	108.8
67.0	41.1	82.5	78.9	79.7	86.2	97.6	112.5	129.8	148.9	168.4
76.3*	63.2	117.1	119.9	125.0	134.5	148.0	165.3	185.6	187.2	172.3

The frequencies given above for $N \geq 2$ are for the structure aft of the payload ring, which in these modes vibrates independently of the capsule shell nose. The corresponding frequencies of the capsule shell nose are all higher and are given in the following table.

N:	2	3	4	5	6	7	8	9	10
	225.6	270.0	354.8	461.0	582.6	718.0	866.3	1027	1200

Case II (Payload Supported Configurations)

Figures 39, 40, and 41, 42 show the displacement amplitudes U, V, W of the lowest three natural vibration modes for N = 0 and 1 for the 120 in. and 165 in. base configurations, respectively. In these plots large discontinuities appear at s = 0 since s = 0- represents the payload end of the adapter shell, whereas s = 0+ represents the base of the capsule shell. In contrast to the results for the Case I configurations, changing the adapter base diameter consistently reduces the natural frequencies for N = 0 and 1 by a small amount except for the lowest axisymmetric mode, which for both base diameters is a torsional mode. These results are summarized in the following table of natural frequencies (cps).

N:	120 in. base		165 in. base	
	0	1	0	1
	38.0*	15.7	38.6*	15.3
	40.5	59.2	38.7	52.4
	70.6	68.9	62.4	68.1

*These frequencies represent torsional vibration modes.

For $N \geq 2$ the rigid payload mass decouples the vibration of the adapter shell, capsule shell overhang (the section aft of the payload ring), and the capsule shell nose. In these modes the payload effectively clamps the edges of each of these three sections. Figures 43 through 51 show the displacement amplitudes U , V , W of the lowest three natural vibration modes for $N = 2$ through 10 for the capsule shell overhang. The minimum frequency of the capsule shell overhang is 13.1 cps in a mode with two circumferential waves. This mode is highly inextensional, as evidenced by the relatively linear variation of modal displacements over the conical part of the shell (see Figure 43a). Whereas the $N = 0$ and 1 modes have large kinetic energies associated with the payload mass, the payload mass has zero kinetic energy in this mode. However, its relatively low kinetic energy is balanced by a relatively low potential energy (mostly bending strain energy), and, as a result, it is the lowest natural mode of the Case II configurations.* The results for the capsule shell overhang are summarized in the following table of natural frequencies (cps).

N:	2	3	4	5	6	7	8	9	10
	13.1	33.0	38.0	43.7	52.9	64.3	77.4	91.9	107.7
	53.0	44.8	71.5	83.7	92.5	109.9	127.2	146.4	167.1
	83.6	79.5	84.3	118.3	140.4	159.1	180.2	203.7	229.0

CONCLUDING REMARKS

The quasi-static stress response during launch and the natural vibration modes of two basic launch configurations for a potential Voyager capsule have been presented. From the point of view of capsule shell stress the payload supported configuration is superior, having a maximum stress only 39 percent of the maximum capsule shell stress in the shell supported configurations. On the other hand, the capsule shell overhang in the payload supported configuration requires a somewhat stiffer base ring to bring the minimum frequency (13.1 cps) of this configuration up to the minimum frequencies (17.1 cps, 18.1 cps) of the shell supported configurations.

* The $N \geq 2$ modes of the adapter shell were not studied but are presumed to have higher frequencies.

REFERENCES

1. Cohen, G. A., "Computer Analysis of Asymmetrical Deformation of Orthotropic Shells of Revolution," AIAA J. 2, May 1964, p. 932.
2. Cohen, G. A., "Computer Analysis of Asymmetric Free Vibrations of Ring-Stiffened Orthotropic Shells of Revolution," AIAA J. 3, December 1965, p. 2305.

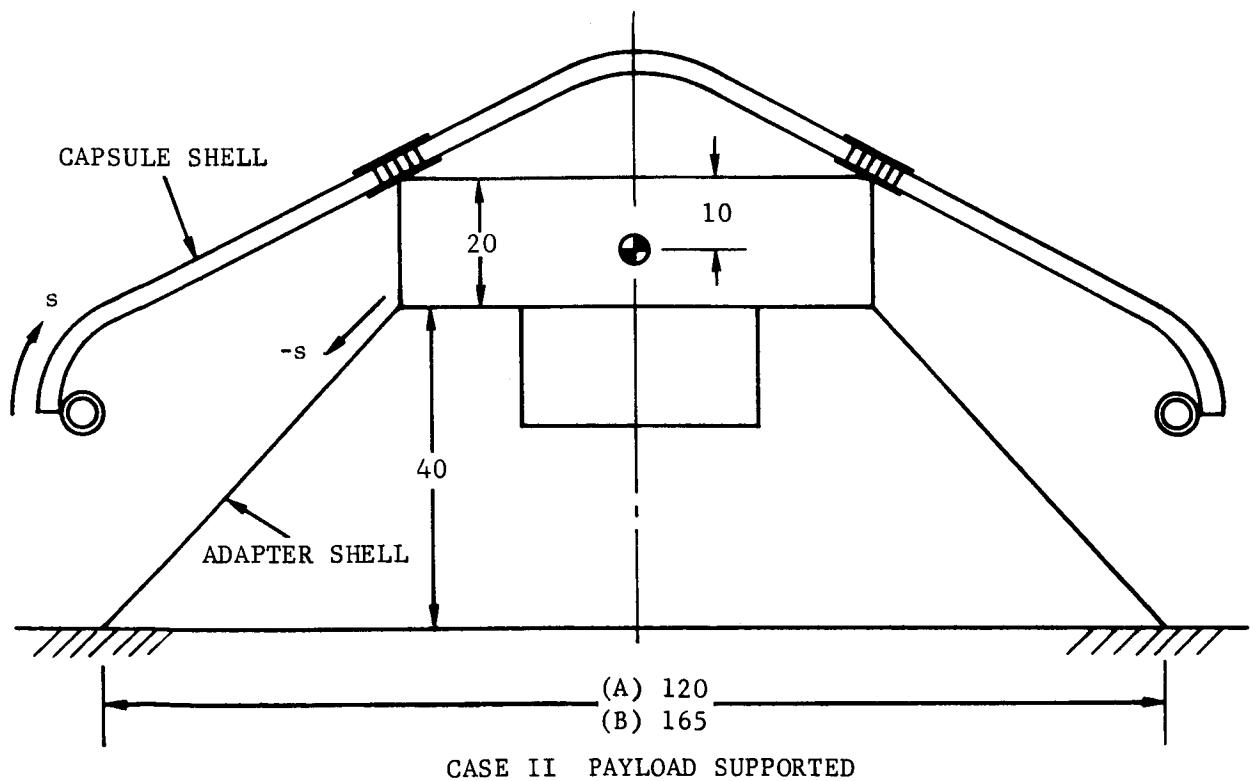
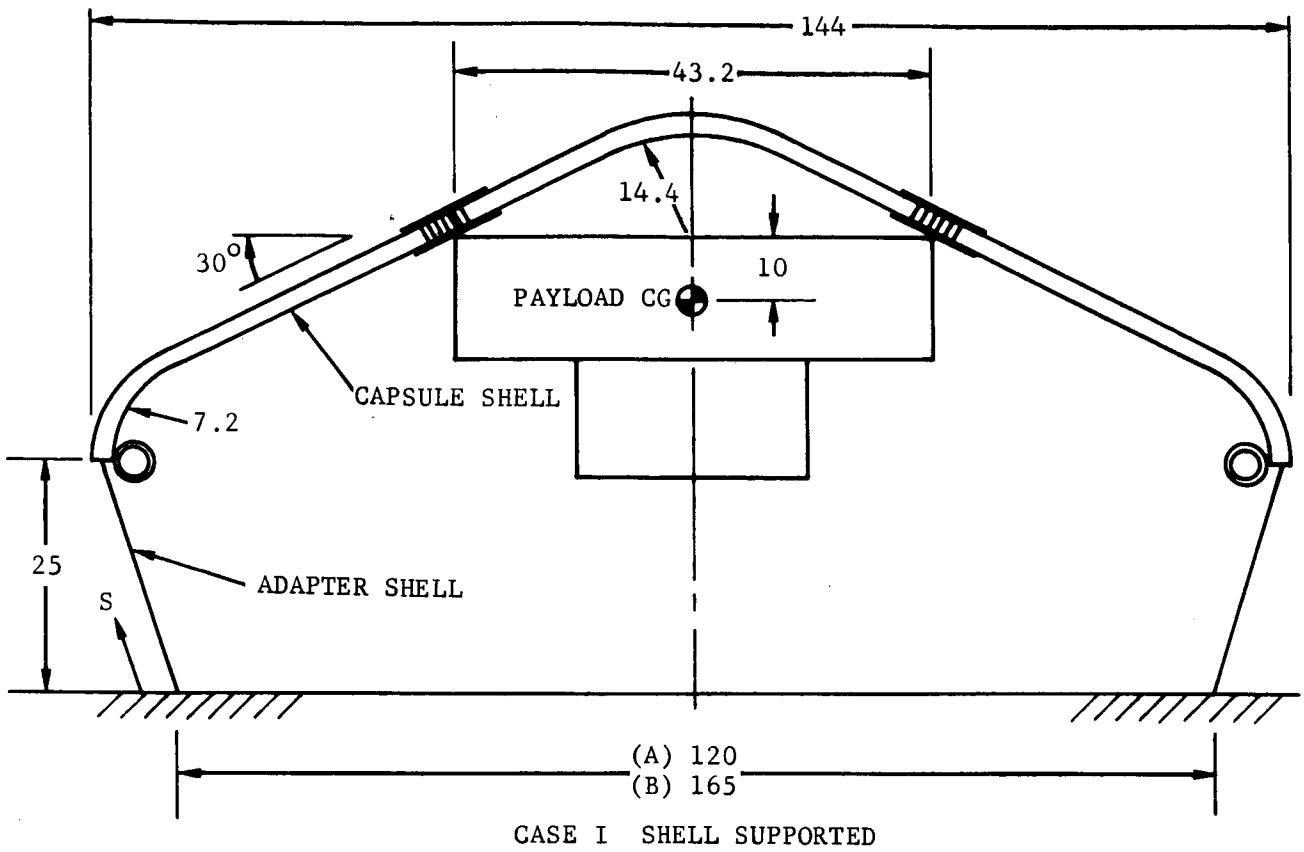


FIGURE 1. CAPSULE LAUNCH CONFIGURATIONS (DIMENSIONS ARE IN INCHES)

FIGURE 2a

MAXIMUM SHELL STRESSES
NASA TASK 3. CASE 1 (1120 IN BASE)
LAYER NO. 1. INNER FACE

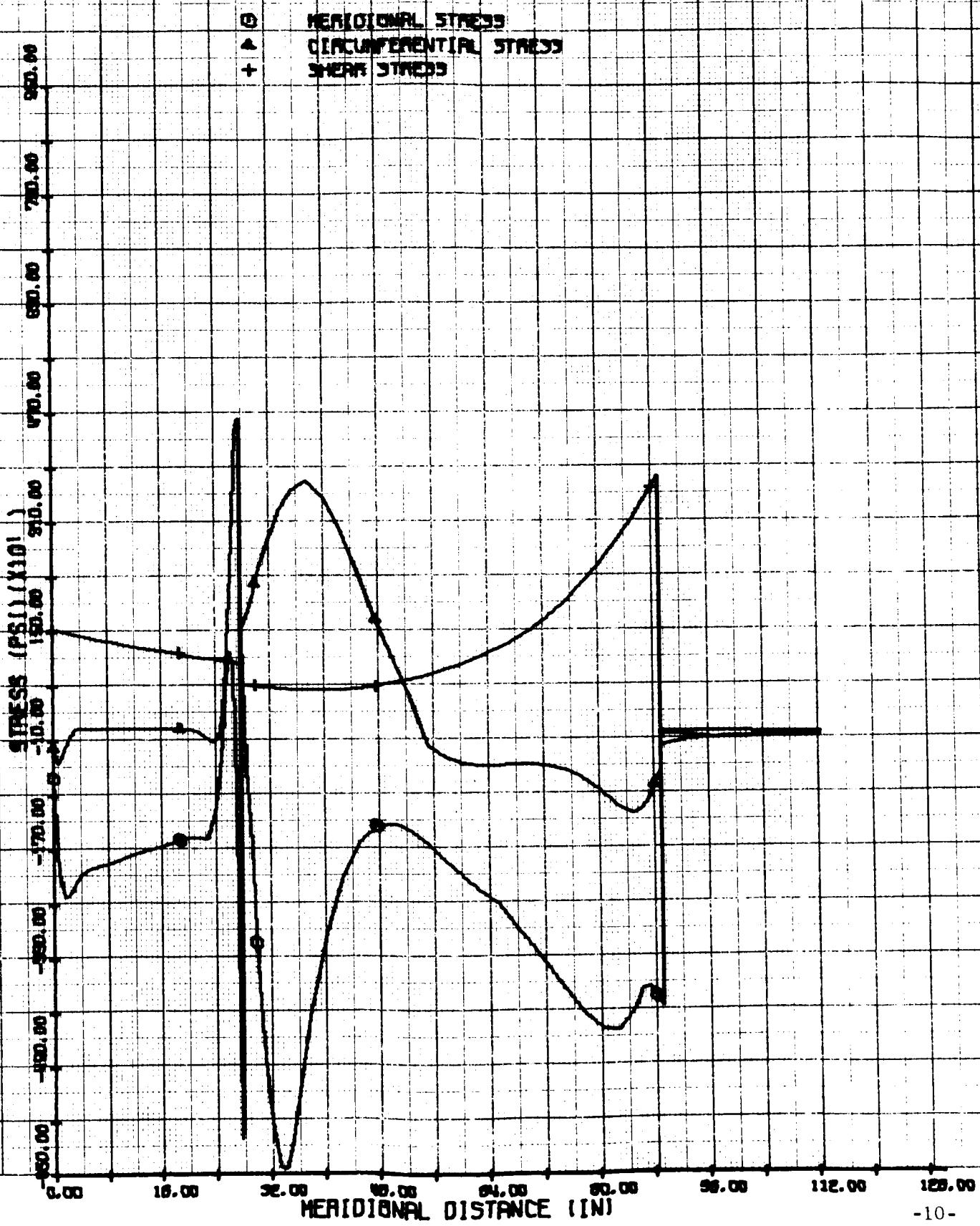


FIGURE 2b
MAXIMUM SHELL STRESSES
NASA TASK 3. CASE 1 (120 IN BASE)
LAYER NO. 1. OUTER FACE

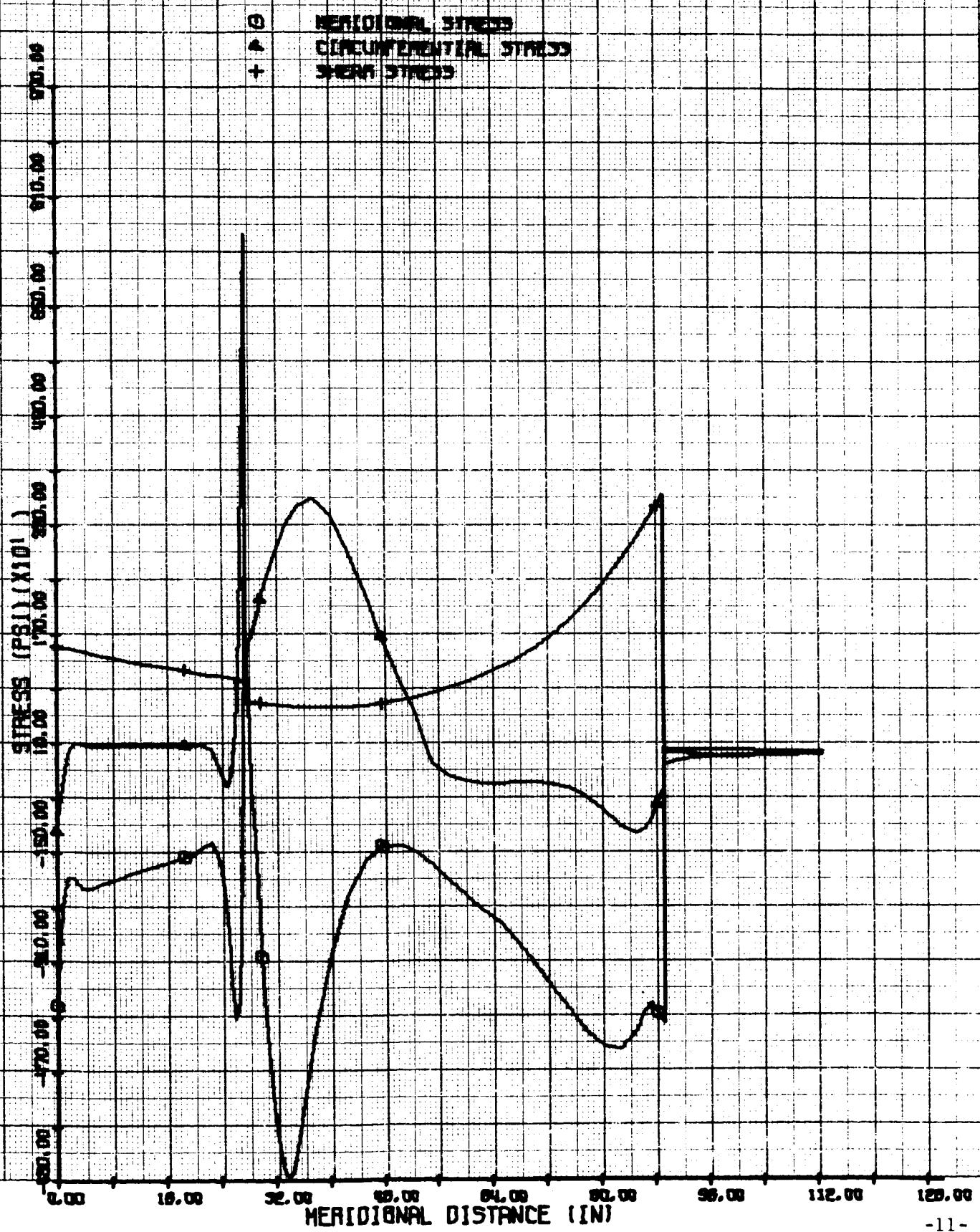


FIGURE 2c

MAXIMUM SHELL STRESSES
NASA TASK 3. CASE 1 (120 IN BASE)
LAYER NO. 3. INNER FACE

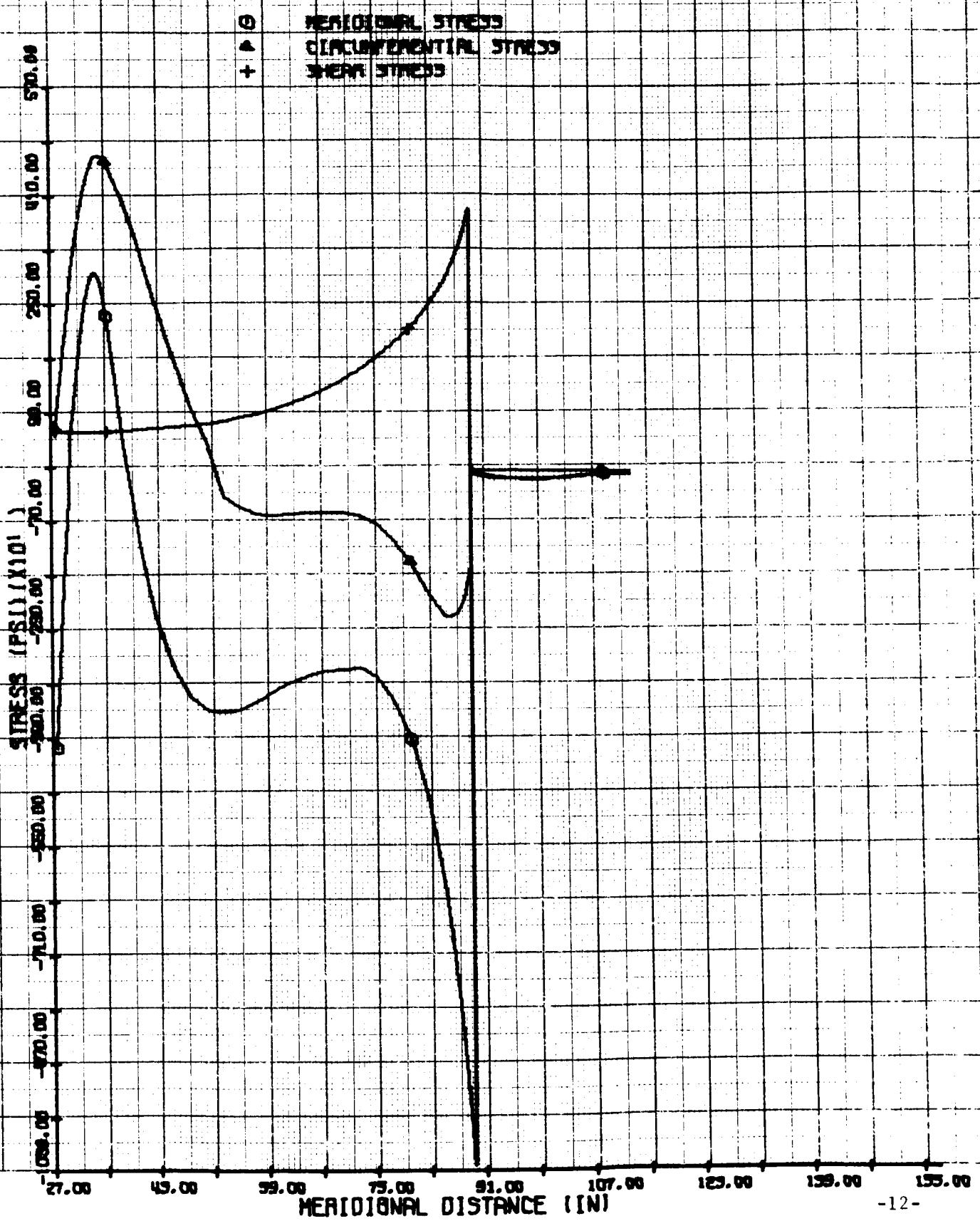


FIGURE 2d

MAXIMUM SHELL STRESSES
NASA TASK 3, CASE 1 (1120 IN BASE)
LAYER NO. 9, OUTER FACE

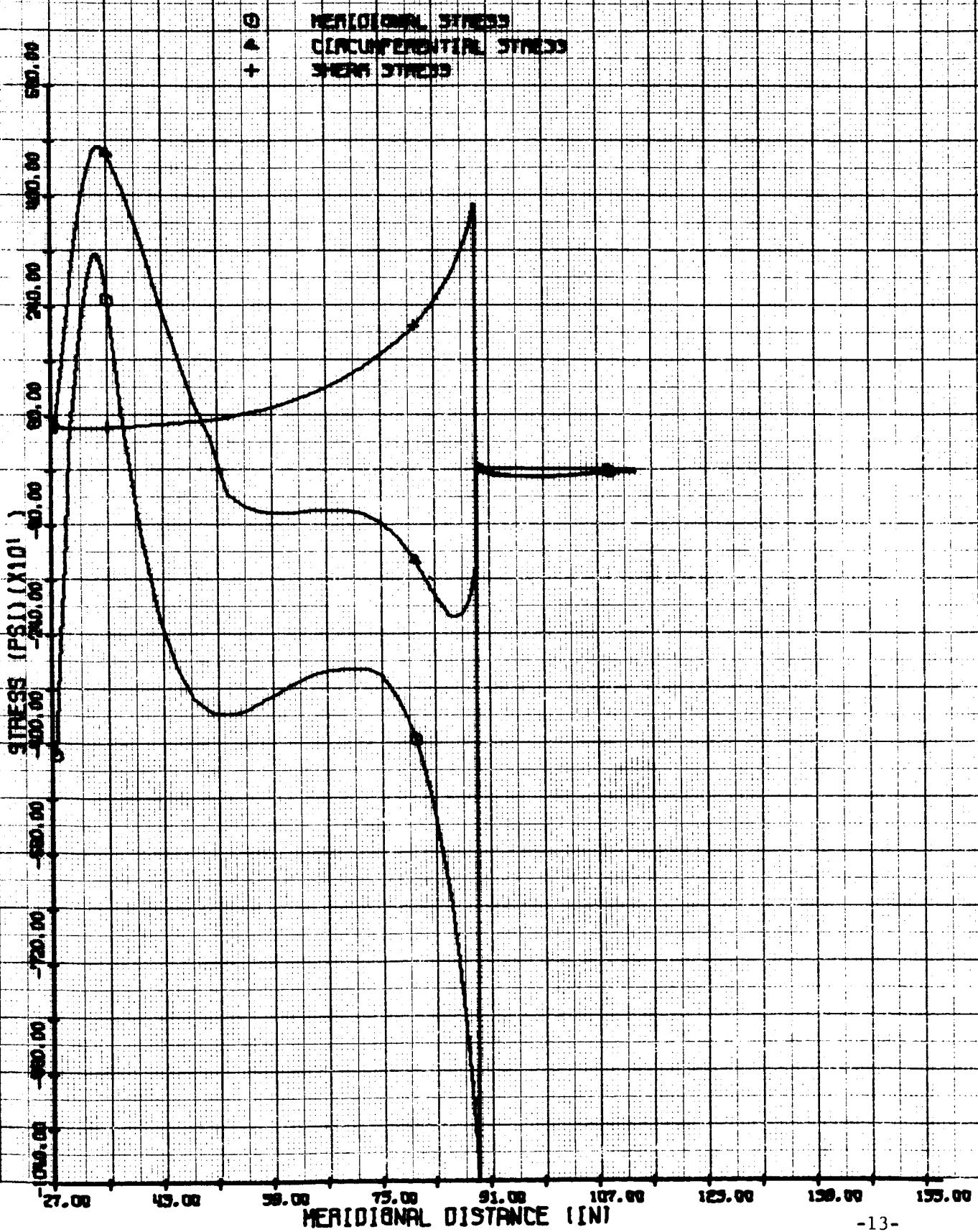


FIGURE 3a

SHELL STRESS AMPLITUDES
NASA TASK 3. CASE 1 (1120 IN. BASE). 10 G AXIAL ACCEL.
LAYER NO. 1. INNER FACE

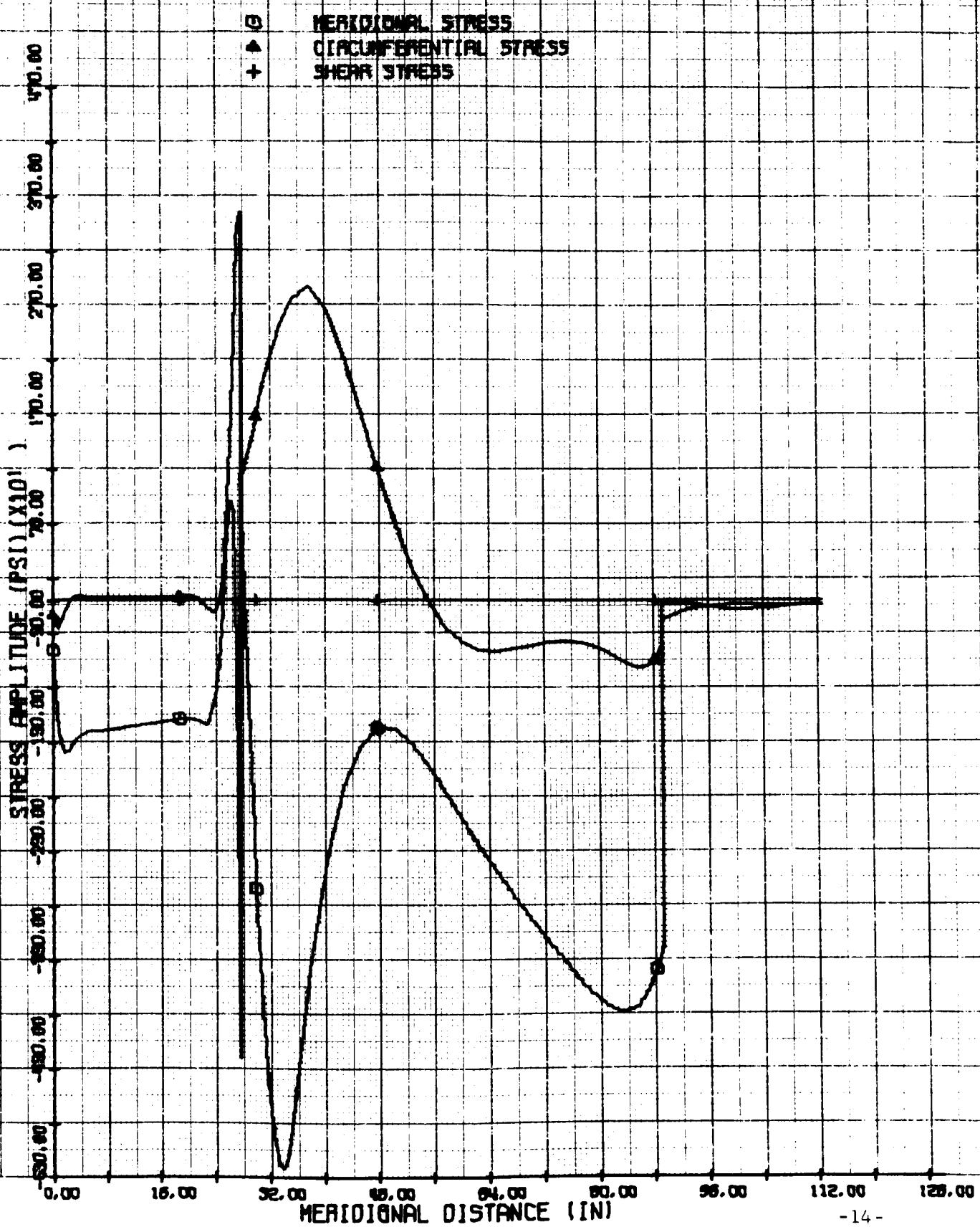


FIGURE 3p

SHELL STRESS AMPLITUDES

NASA TASK 3. CASE 1 (120 IN. BASE). 10 G AXIAL ACCEL.

LAYER NO. 1. OUTER FACE

- MERIDIONAL STRESS
- ▲ CIRCUMFERENTIAL STRESS
- + SHEAR STRESS

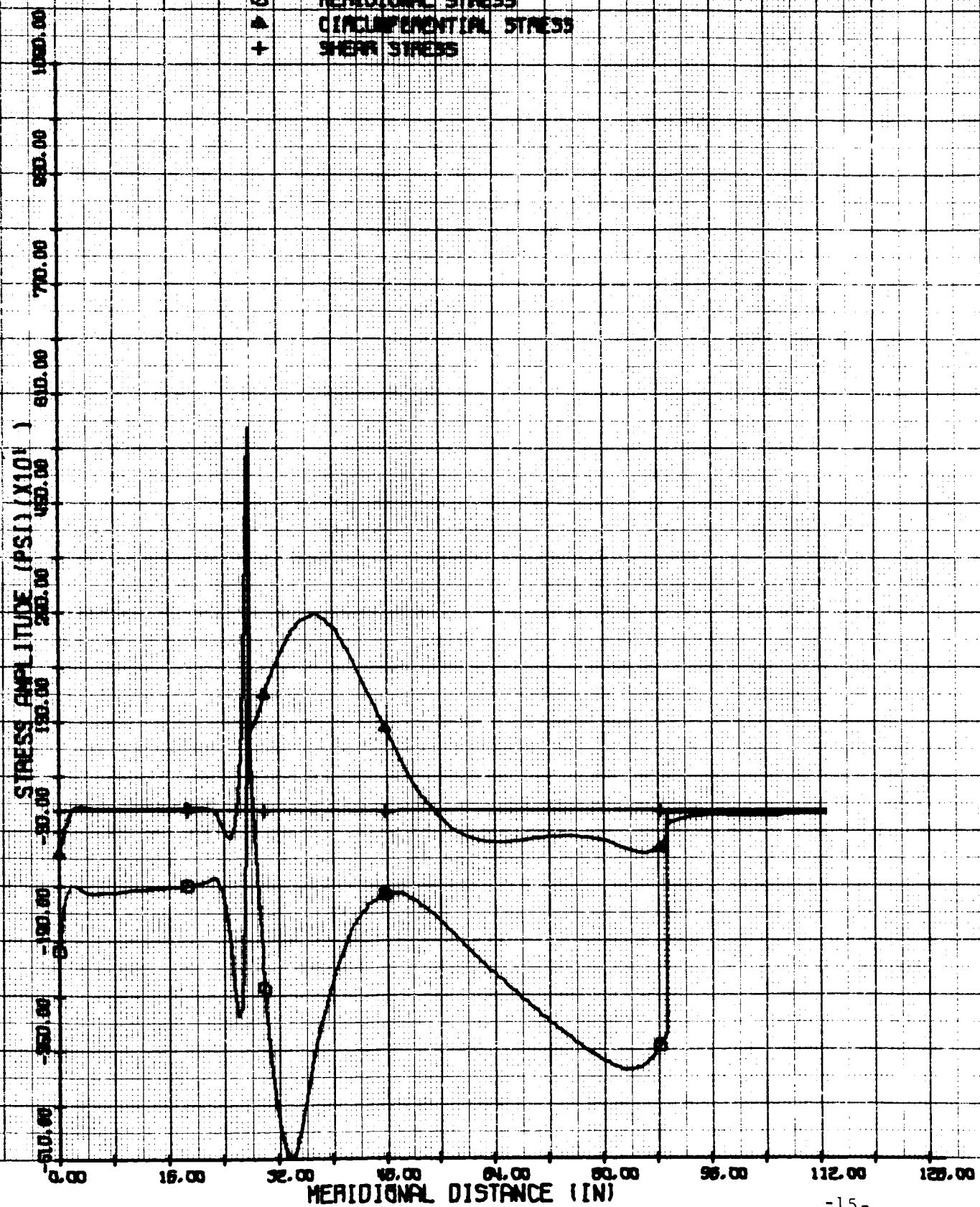


FIGURE 3c

SHELL STRESS AMPLITUDES
NASA TASK 3. CASE 1 1120 IN. BASE1. 10 G RADIAL ACCEL.
LAYER NO. 3. INNER FACE

○ MERIDIONAL STRESS
▲ CIRCUMFERENTIAL STRESS
+ SHEAR STRESS

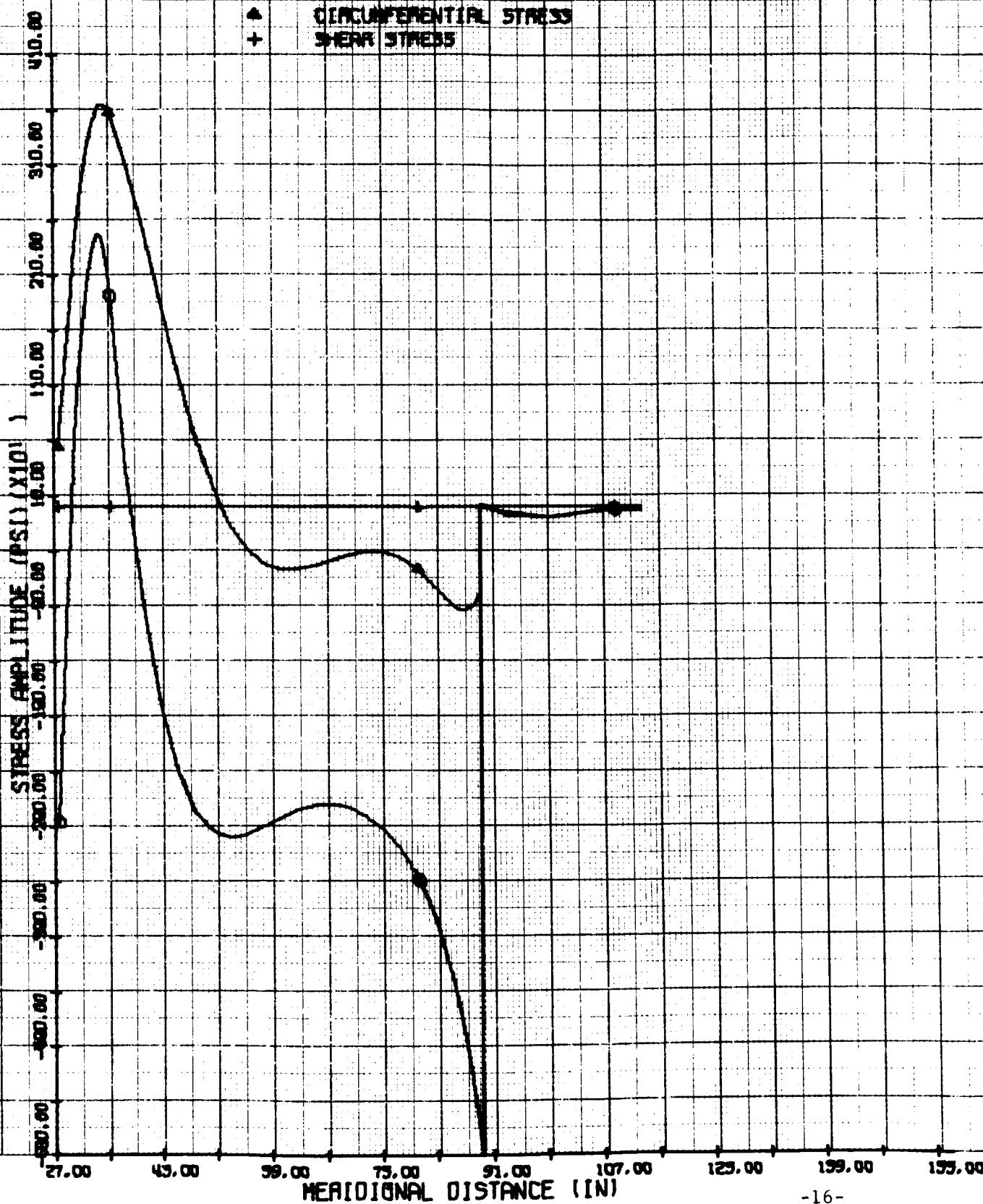


FIGURE 3d

SHELL STRESS AMPLITUDES

NASA TASK 3. CASE 1 1120 IN. BASE1. 10 G AXIAL ACCEL.
LAYER NO. 3. OUTER FACE

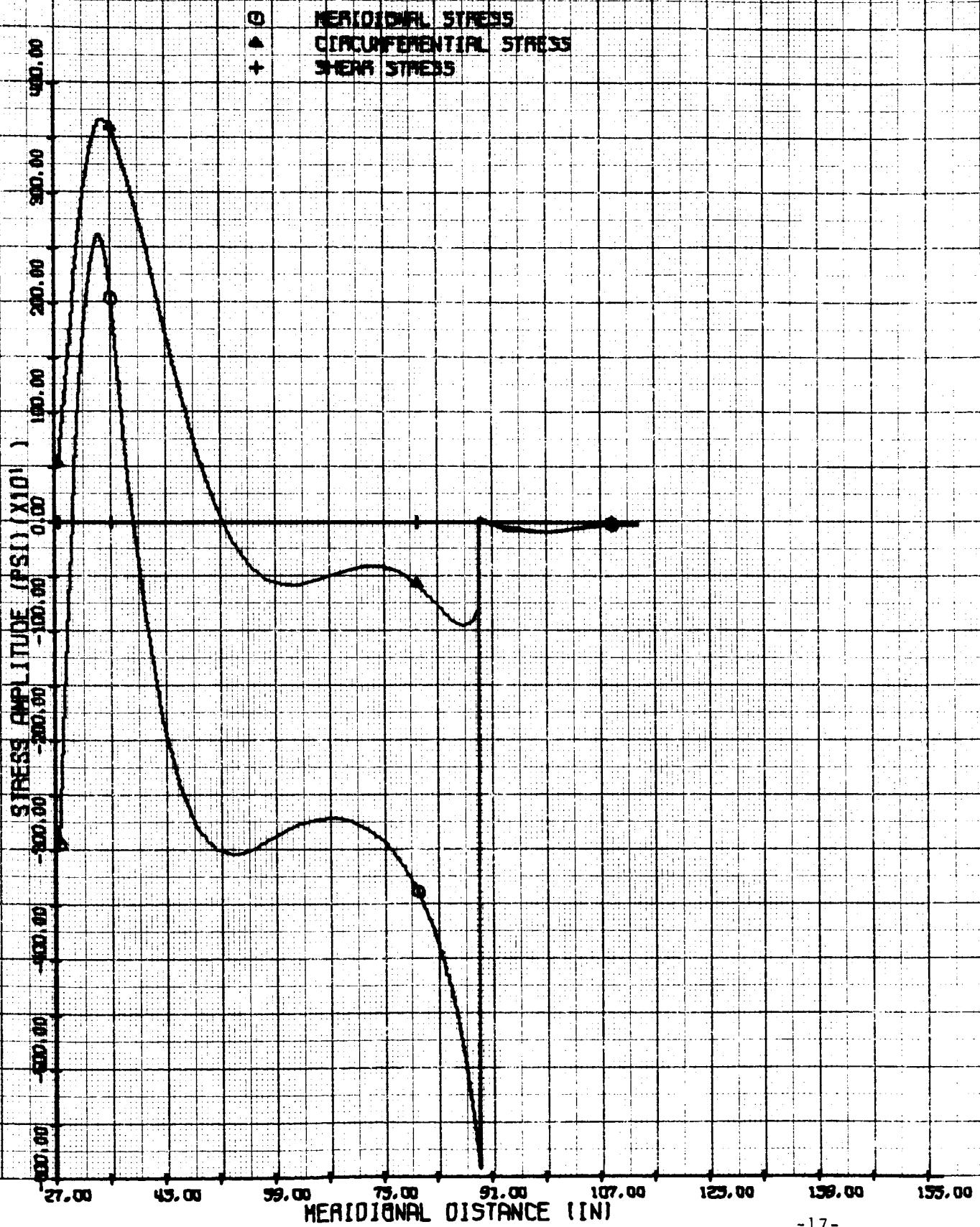


FIGURE 4a

SHELL STRESS AMPLITUDES
NASA TASK 3. CASE I (120 IN BASE). 5 G LATERAL ACCEL
LAYER NO. 1. INNER FACE

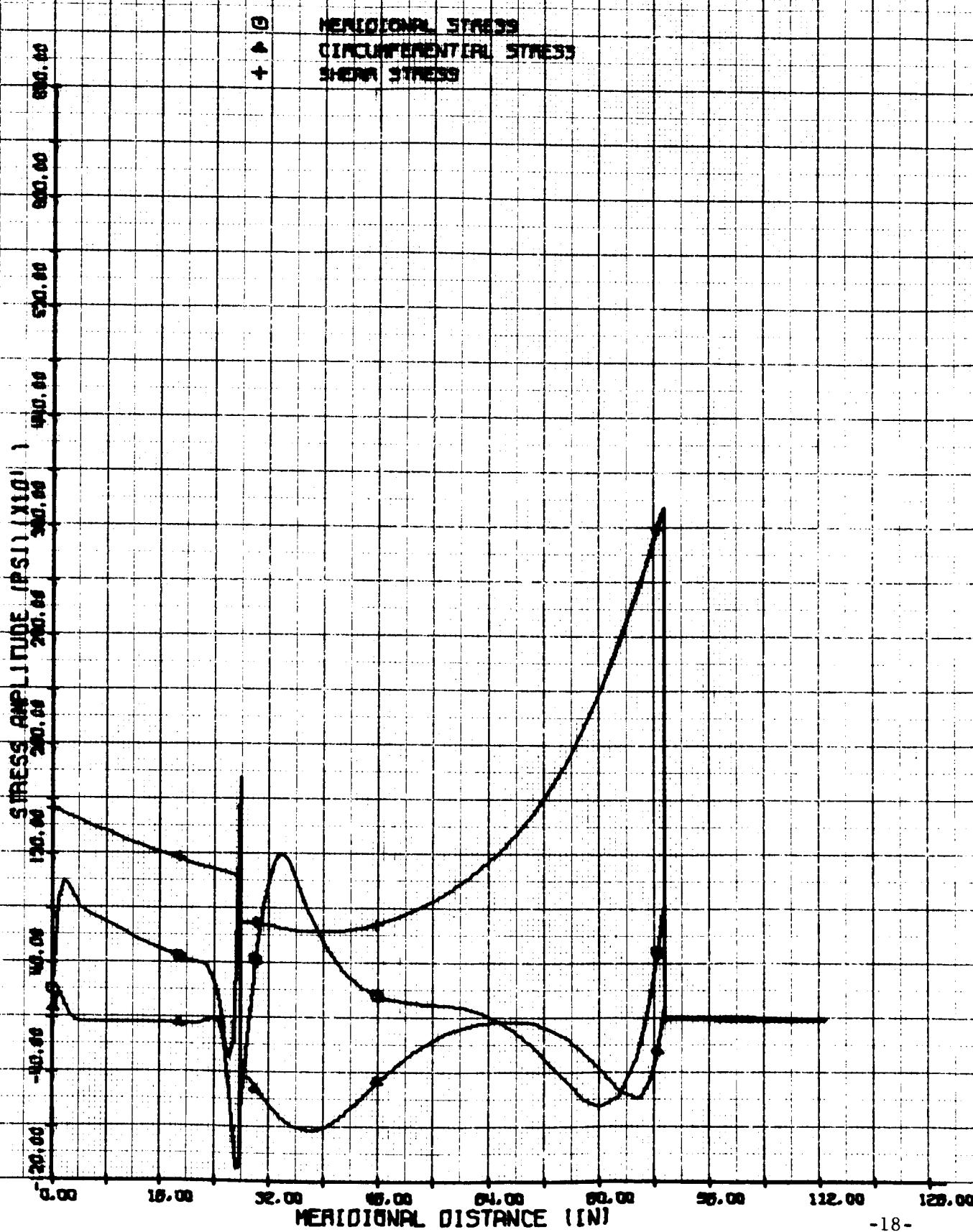


FIGURE 4b

SHELL STRESS AMPLITUDES

NASA TASK 3. CASE 1 (1120 IN BASE). 5 G LATERAL ACCEL.
LAYER NO. 1. OUTER FACE

- MERIDIONAL STRESS
- × CIRCUMFERENTIAL STRESS
- + SHEAR STRESS

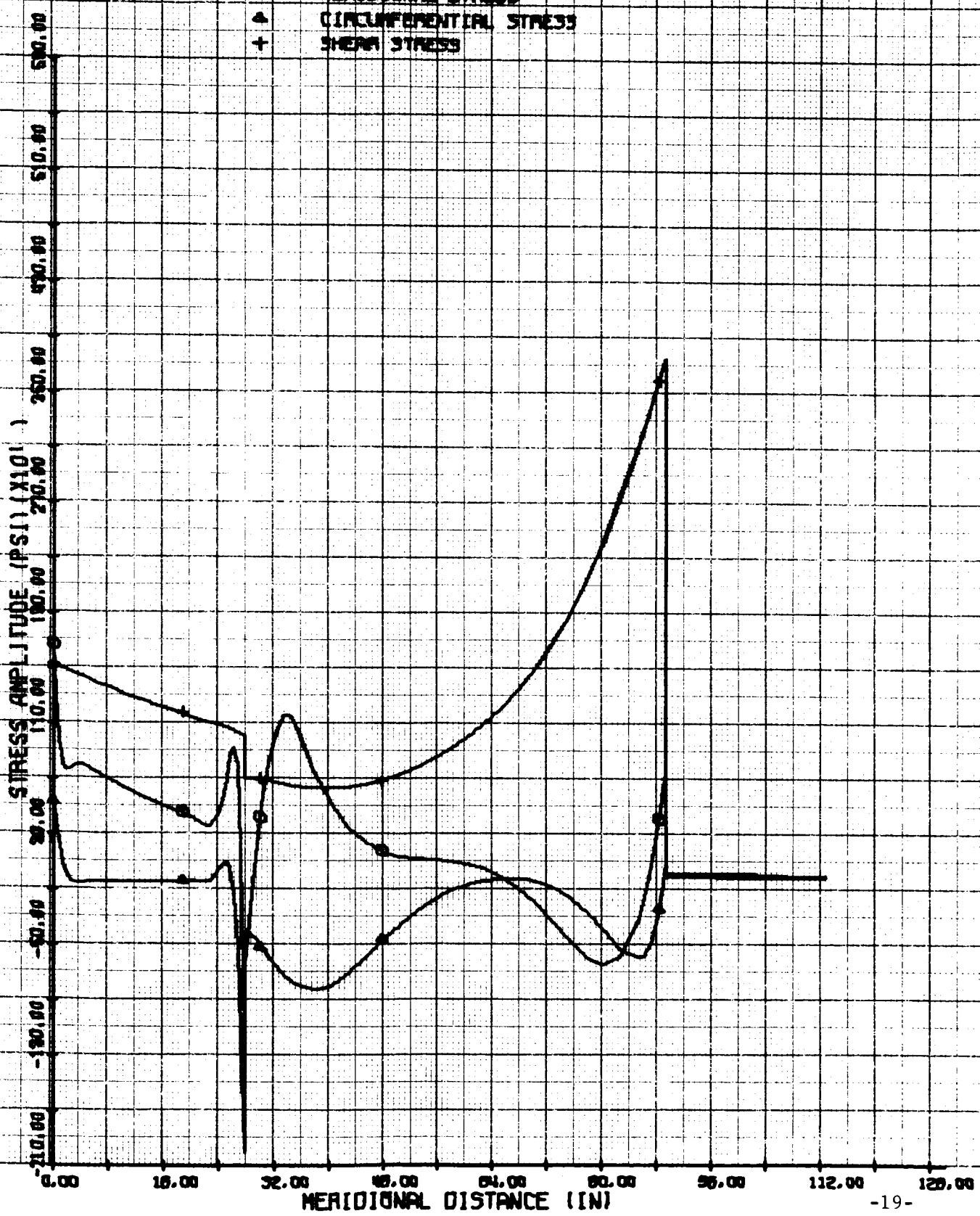


FIGURE 4c
SMELL STRESS AMPLITUDES
NASA TASK 3. CASE I 1120 IN BASE1. 5 G LATERAL ACCEL
LAYER NO. 3. INNER FACE

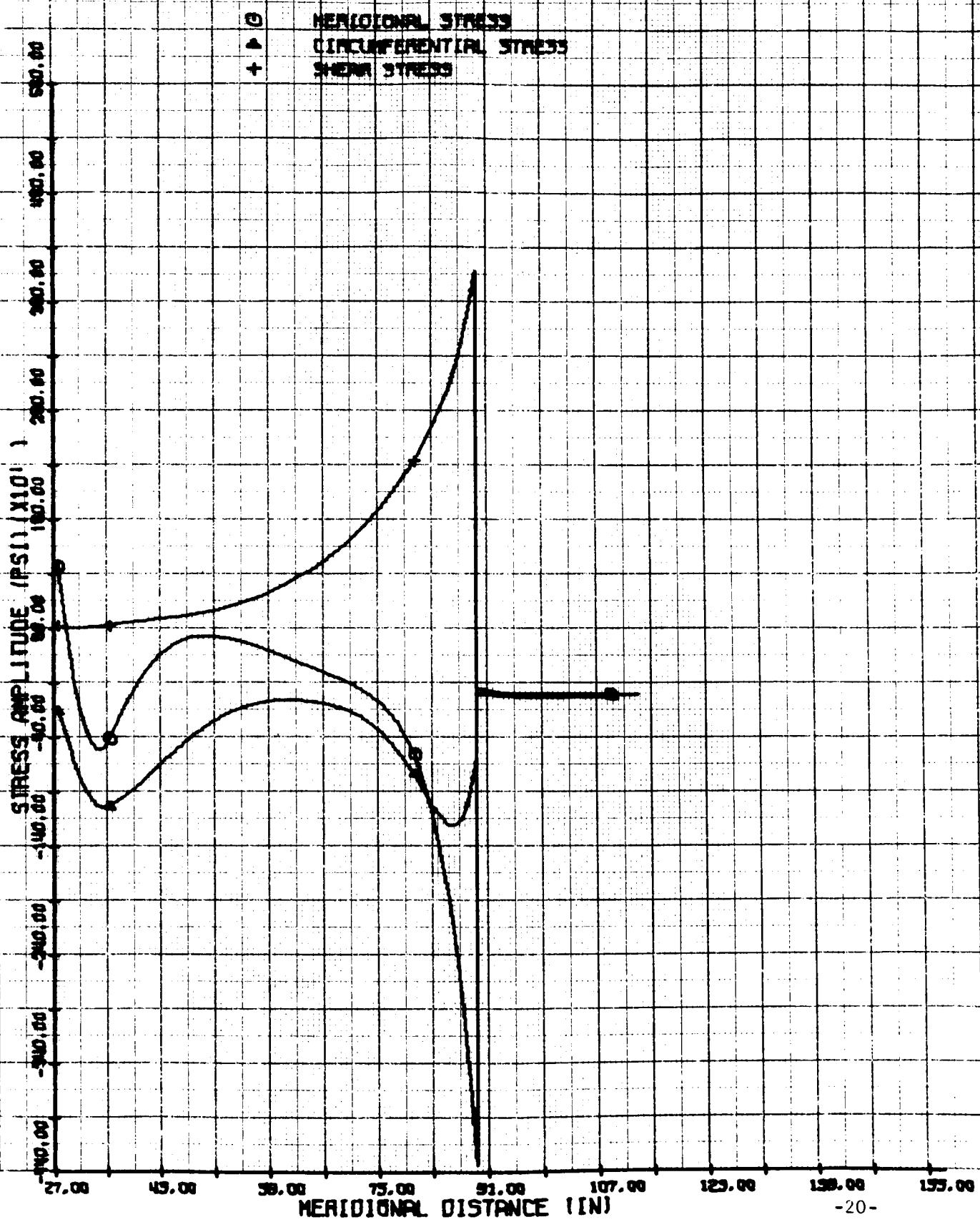


FIGURE 4d

SHELL STRESS AMPLITUDES

NASA TASK 3. CASE 1 (120 IN BASE). 5 G LATERAL ACCEL
LAYER NO. 3. OUTER FACE

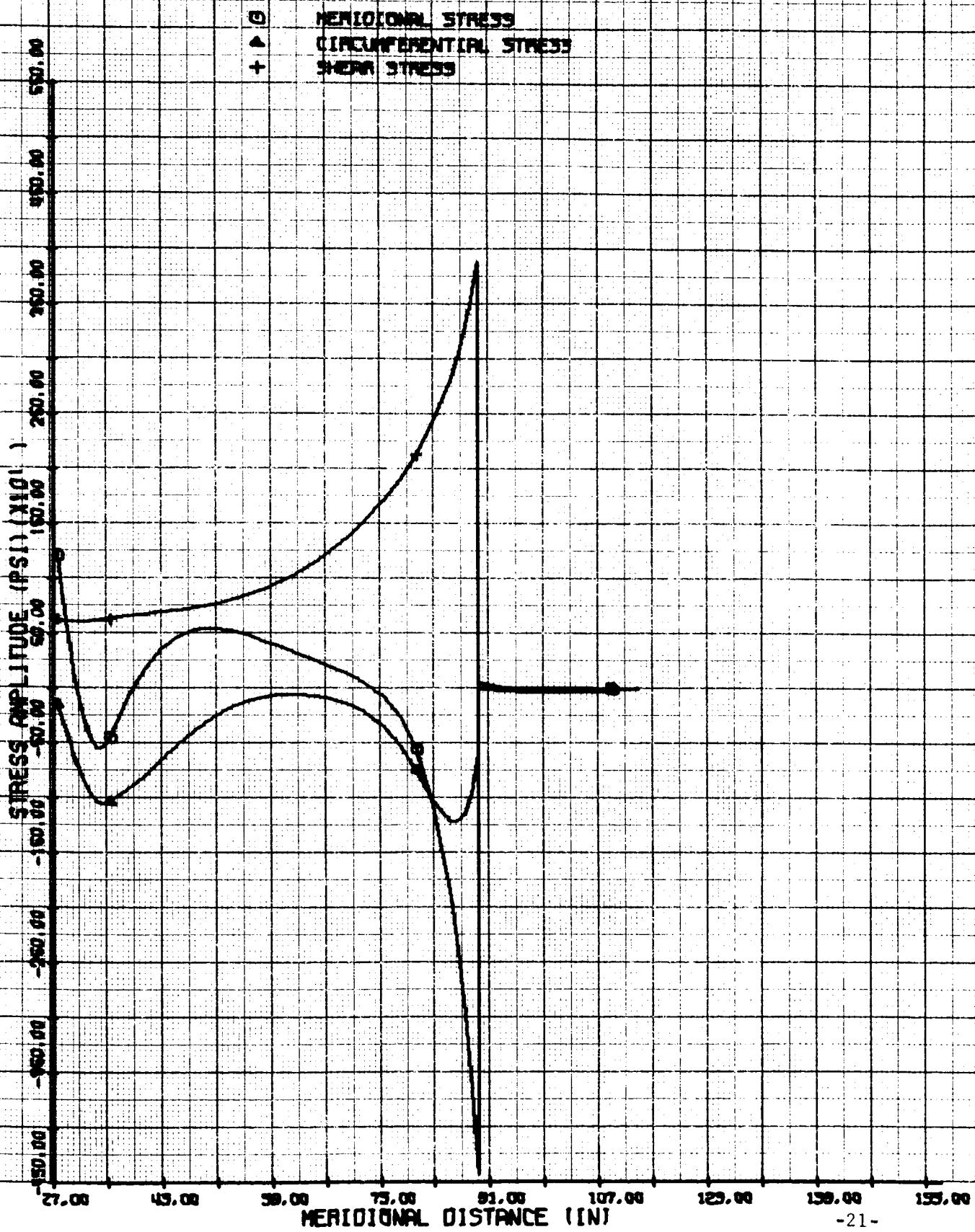


FIGURE 5a

MAXIMUM SHELL STRESSES
NASA TASK 3. CASE 1 (165 IN. ERSE)
LAYER NO. 1, INNER FACE

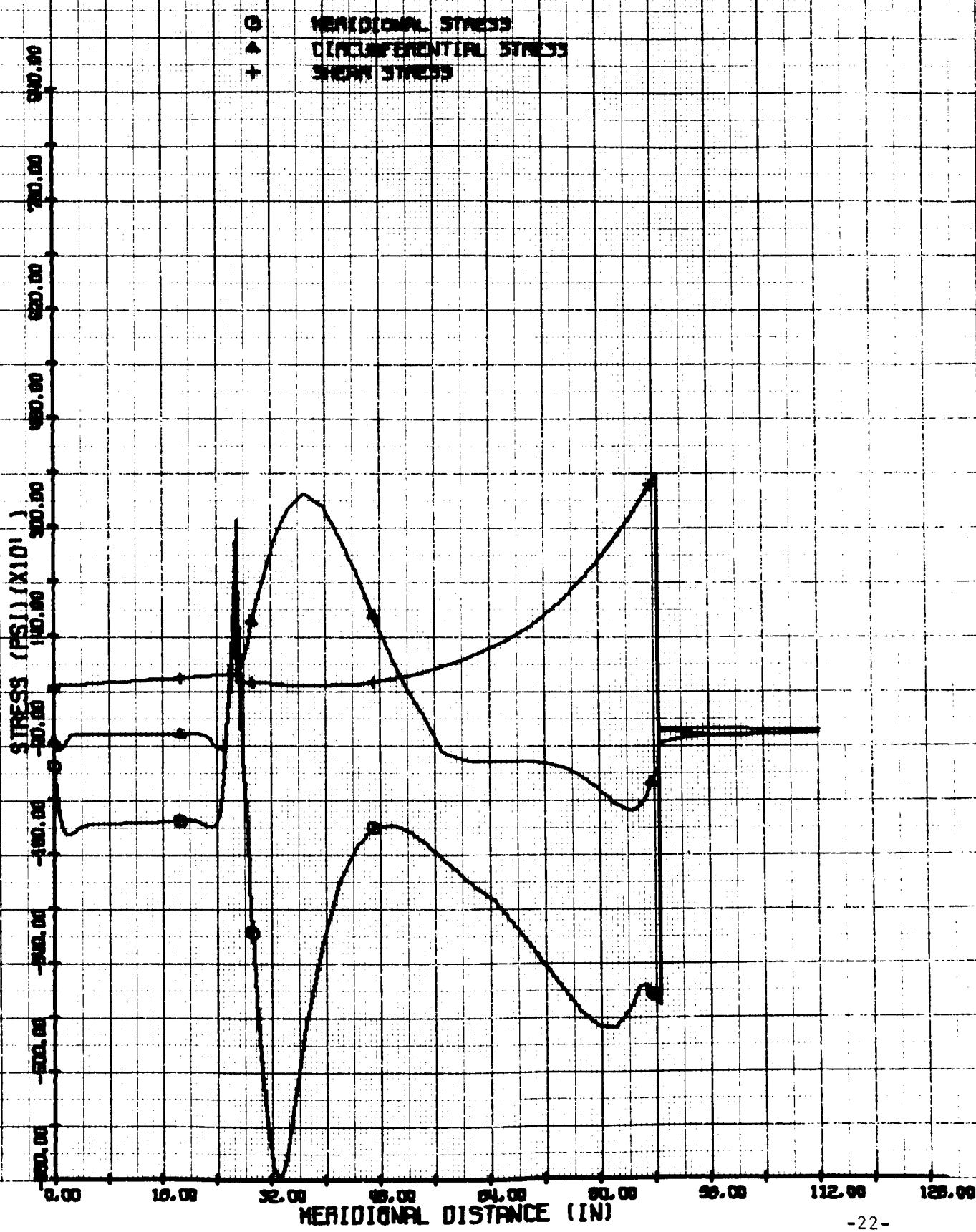


FIGURE 5b
MAXIMUM SHELL STRESSES
NASA TASK 3. CASE 1 (165 IN. BASE)
LAYER NO. 1. OUTER FREE

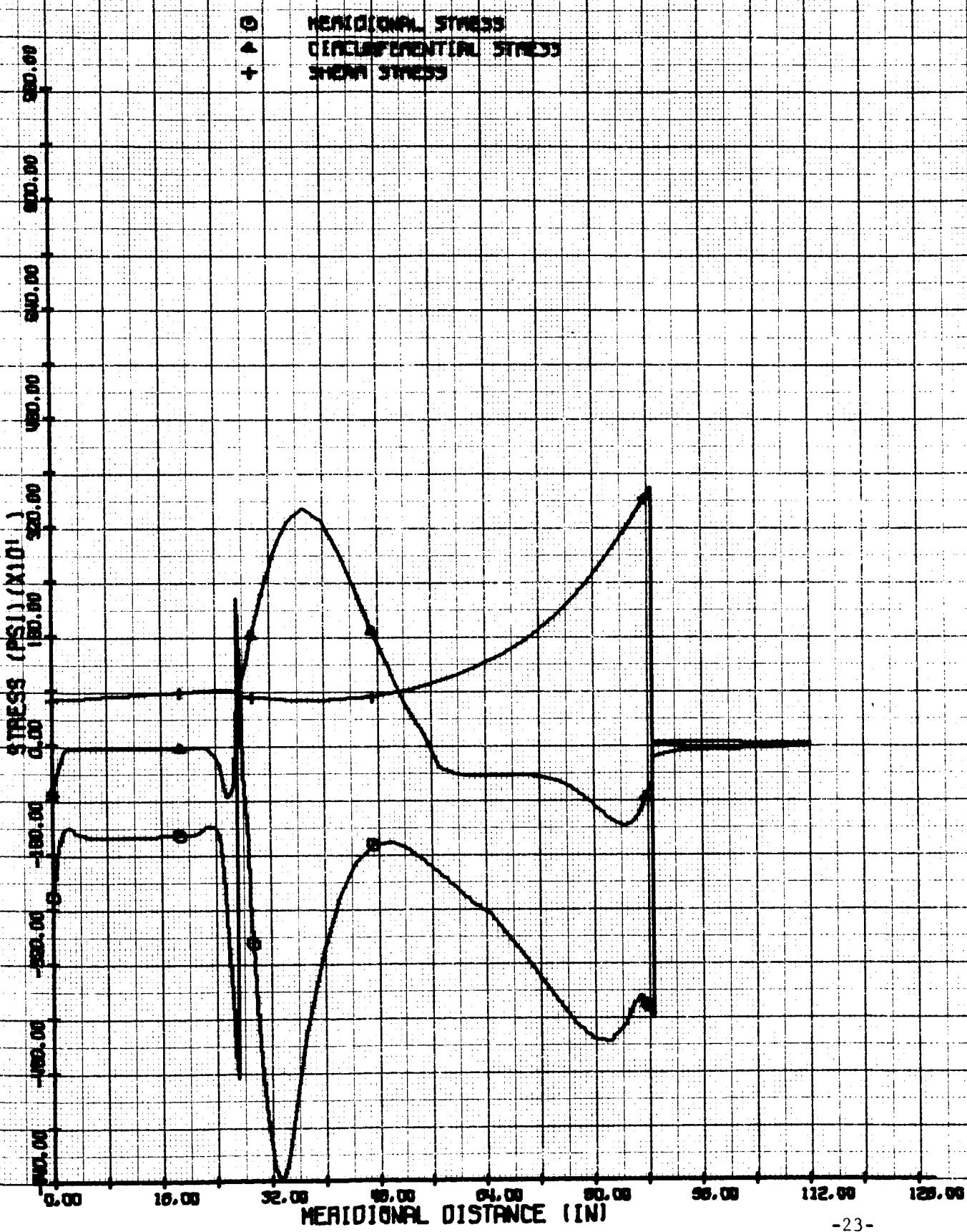


FIGURE 5C

MAXIMUM SHELL STRESSES
NASA TASK 3. CASE 1 1165 IN. BASE 1
LAYER NO. 3. INNER FACE

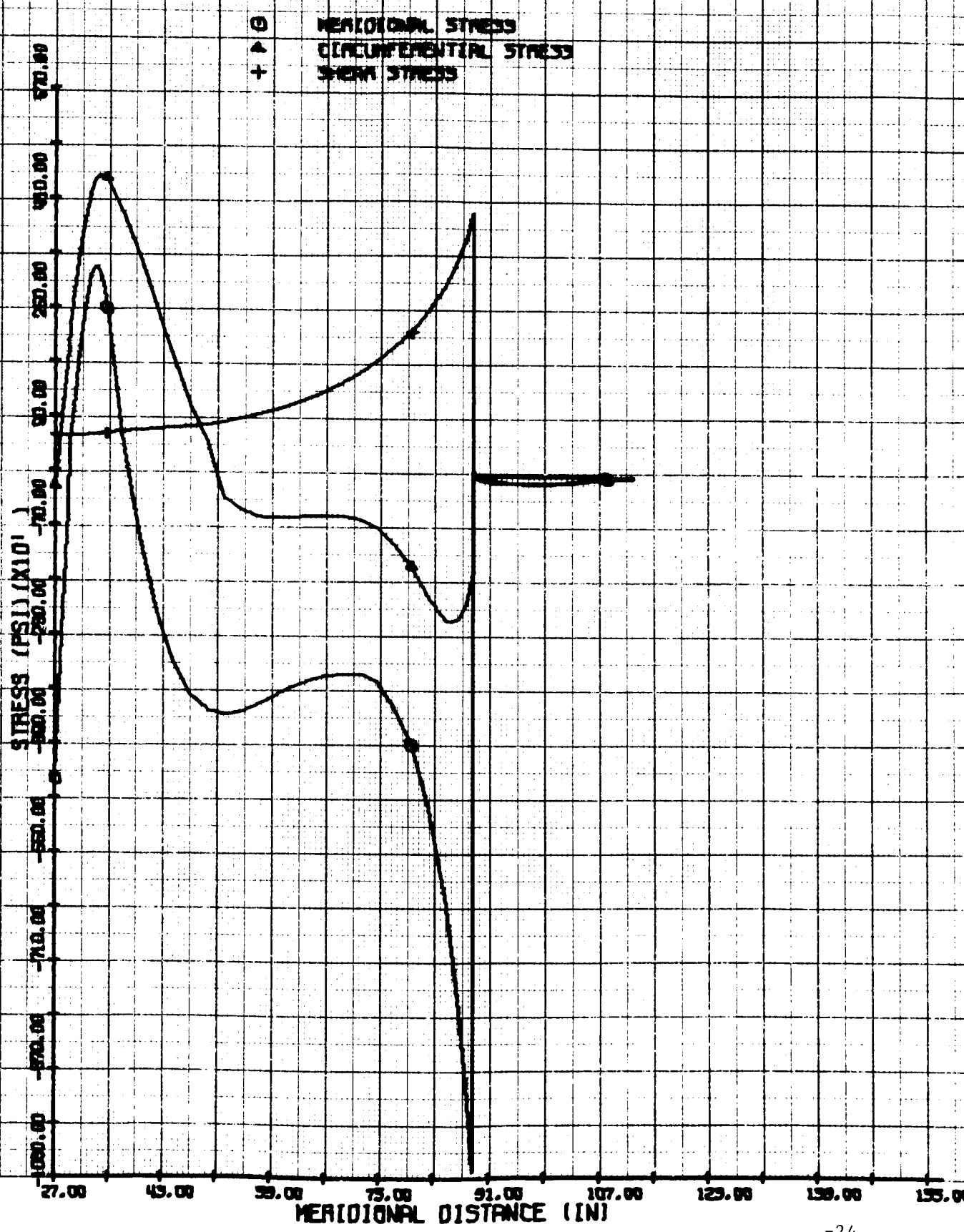


FIGURE 54
MAXIMUM SHELL STRESSES
NASA TASK 3. CASE 1 (165 IN. BASE)
LAYER NO. 1. OUTER FACE

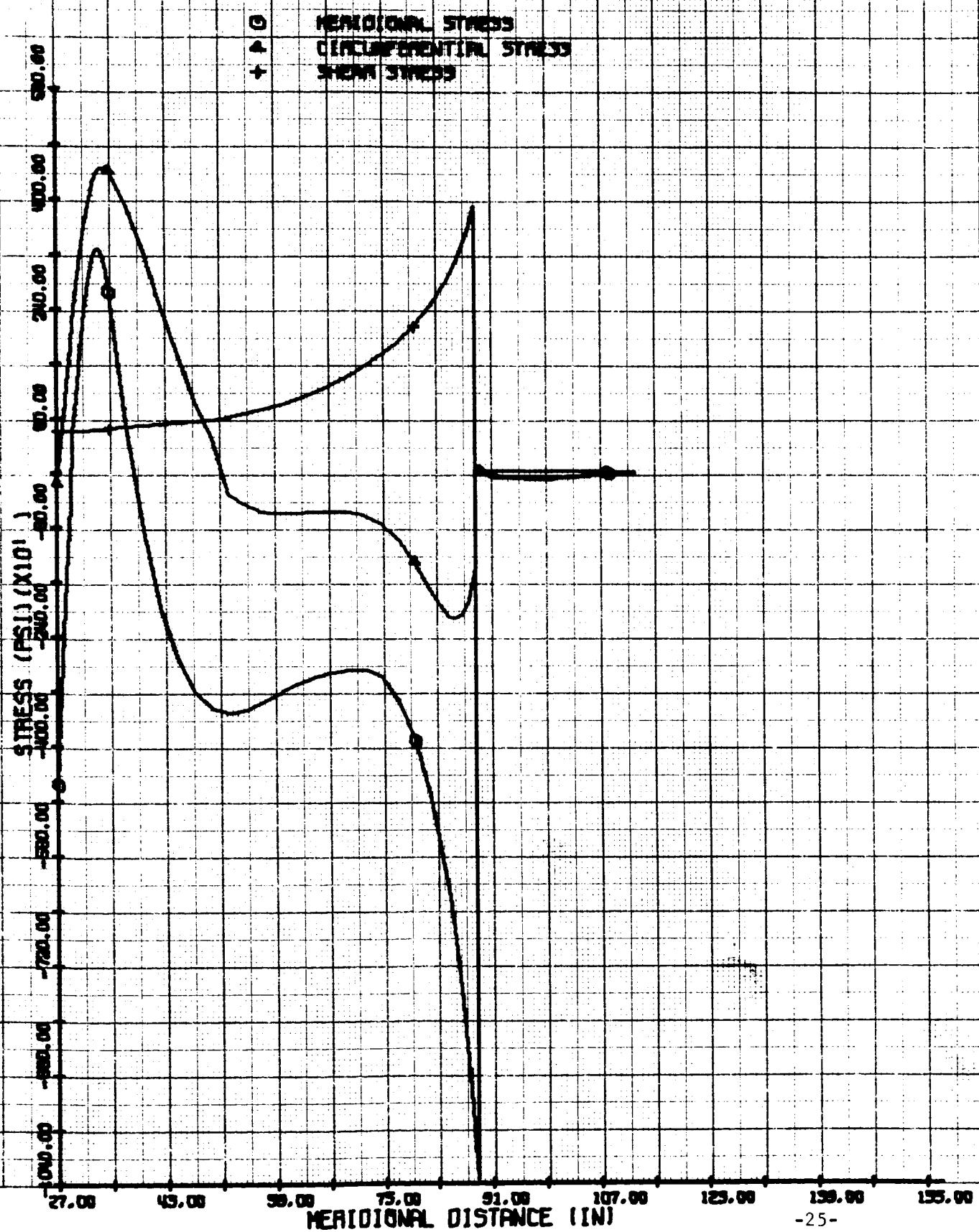


FIGURE 6a

SHELL STRESS AMPLITUDES

NASA TASK 3. CASE I (165 IN. BASE). 10 G AXIAL ACCEL.
LAYER NO. 1. INNER FACE

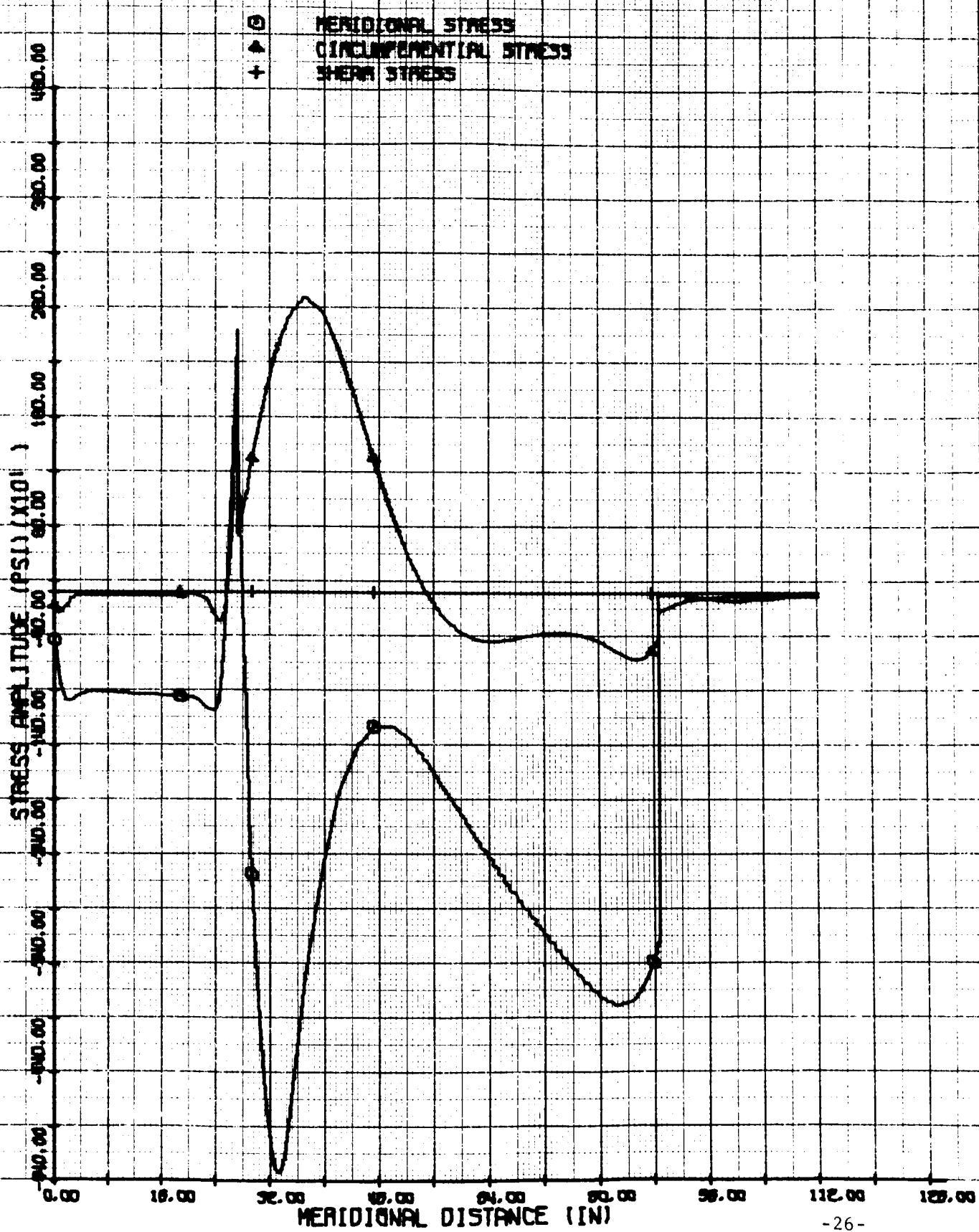


FIGURE 66

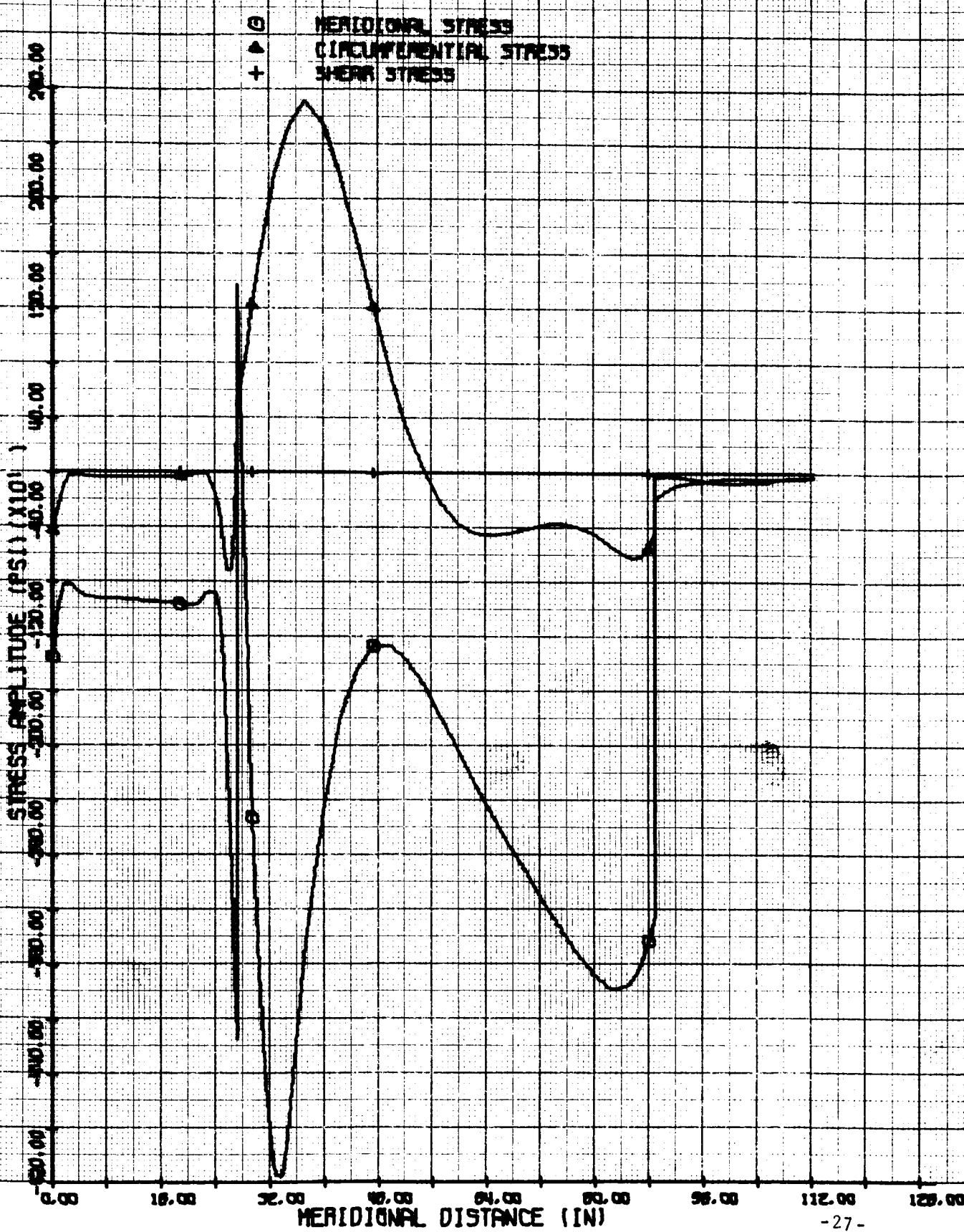
SHELL STRESS AMPLITUDESNASA TASK 3. CASE 1 (165 IN. BASE). 10 G AXIAL ACCEL.
LAYER NO. 1. OUTER FACE

FIGURE 6c

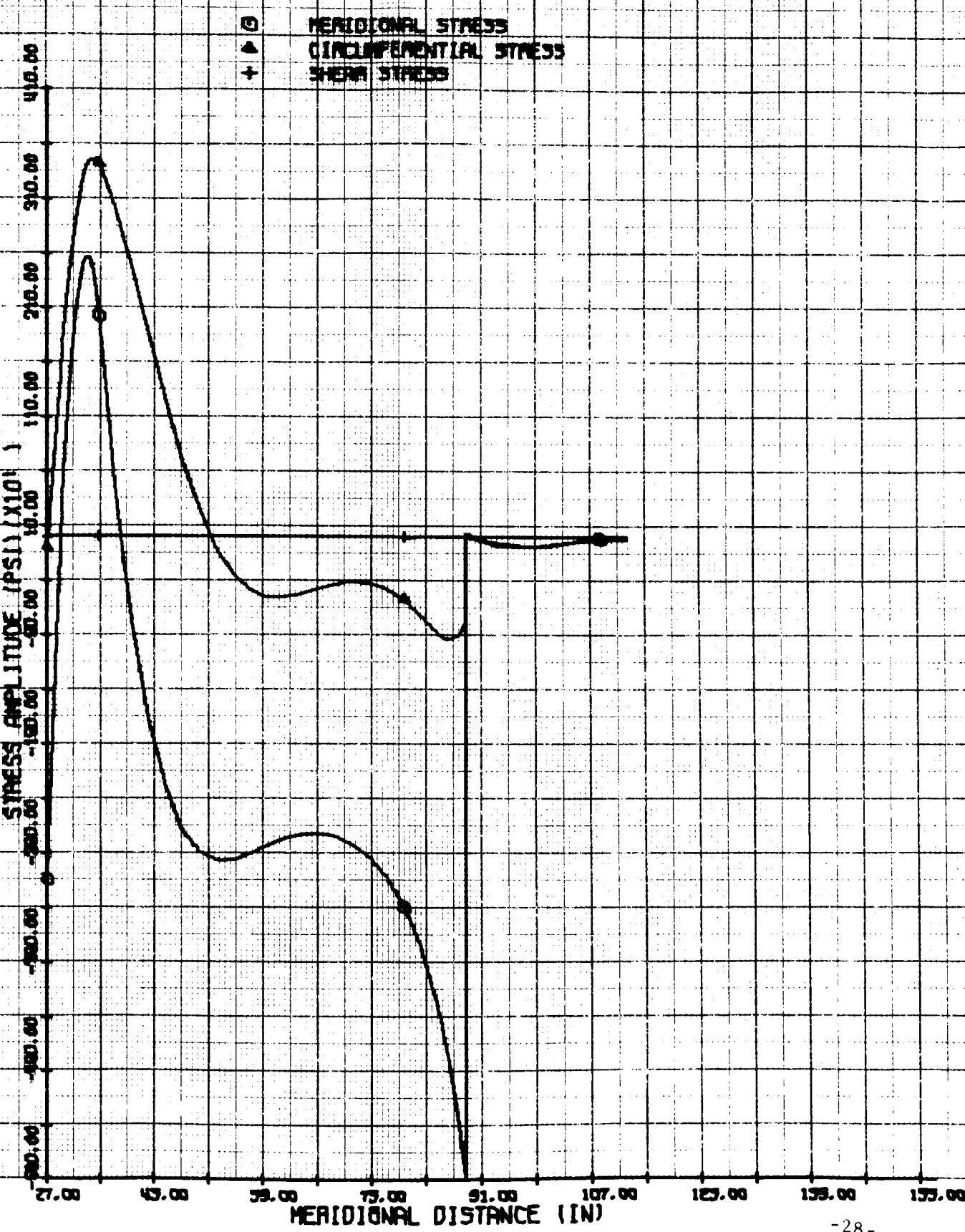
SHELL STRESS AMPLITUDESNASA TASK 3. CASE I (165 IN. BRSE). 10 G AXIAL ACCEL.
LAYER NO. 3. INNER FACE

FIGURE 68

SHELL STRESS AMPLITUDES

NASA TASK 3. CASE 1. 1165 IN. BASE1. 10 G AXIAL ACCEL.
LAYER NO. 3. OUTER FACE

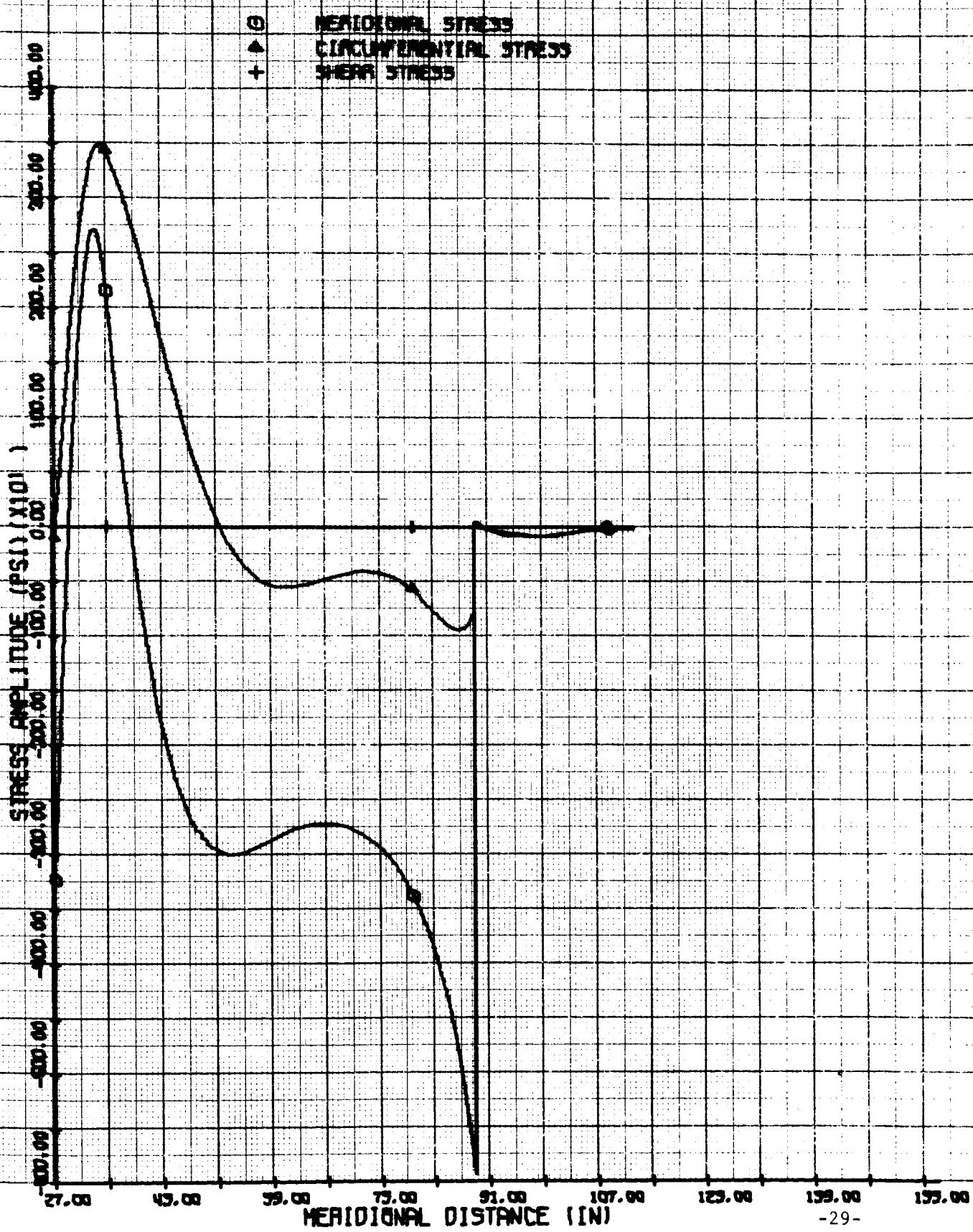


FIGURE 7a

SMALL STRESS AMPLITUDES

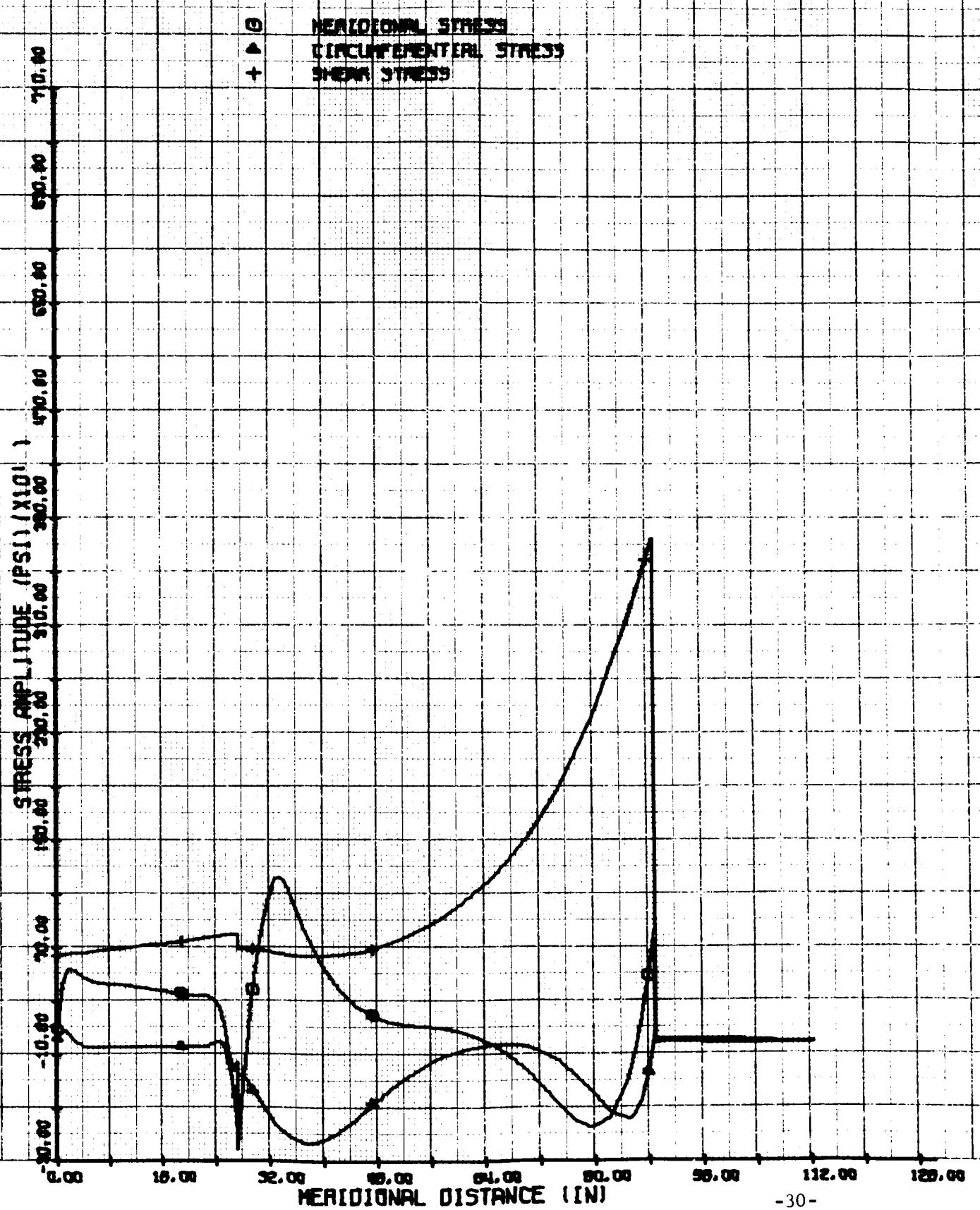
NASA TASK 3. CASE 1 (165 IN BASE). 5 G LATERAL ACCEL
LAYER NO. 1. INNER FACE

FIGURE 7b
SHELL STRESS AMPLITUDES
NASA TASK 3. CASE 1 (165 IN BASE). 5 G LATERAL ACCEL
LAYER NO. 1. OUTER SURFACE

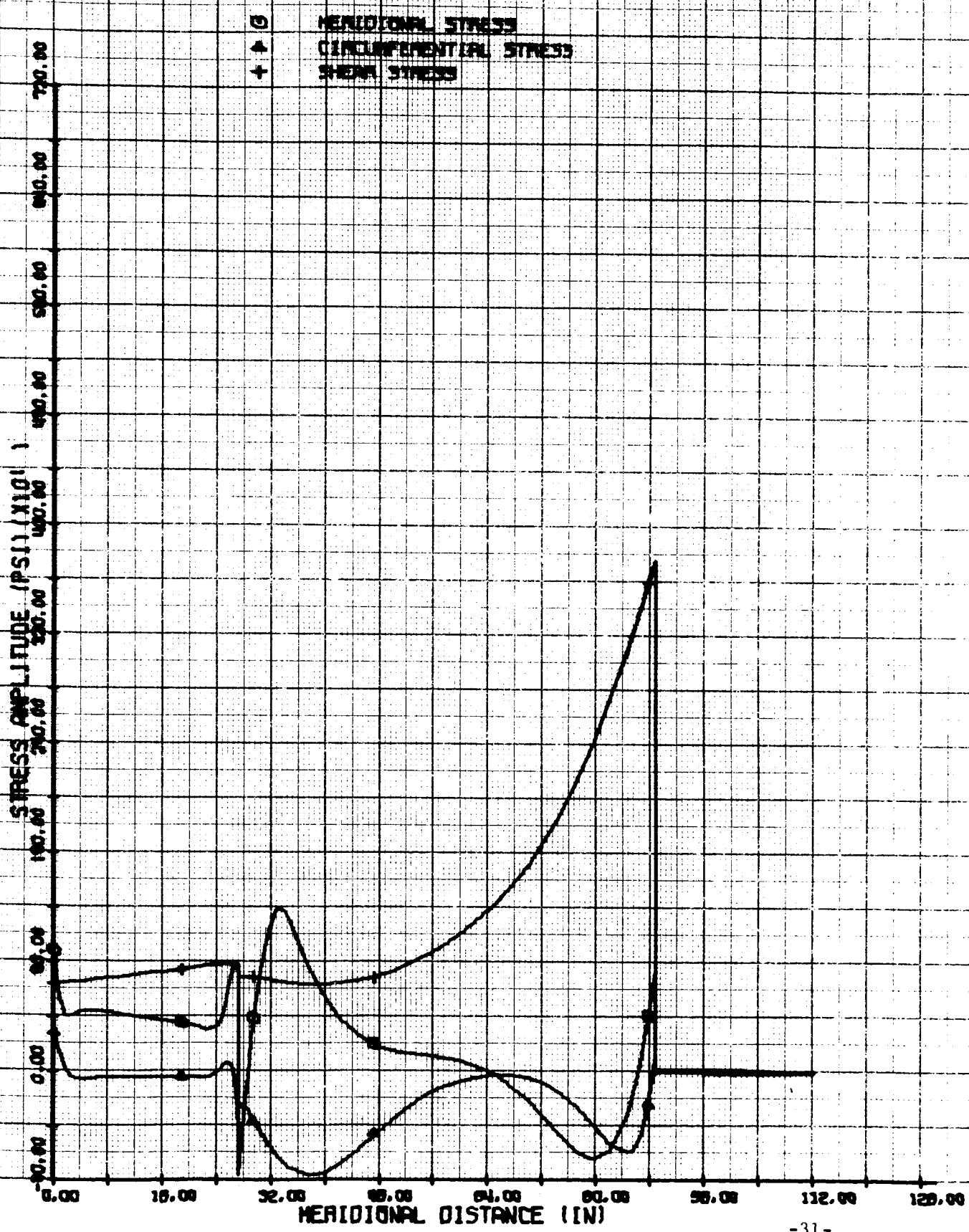


FIGURE 7c

SHELL STRESS AMPLITUDES

NASA TASK 3. CASE I (165 IN BASE). 5 G LATERAL ACCEL
 LAYER NO. 3. INNER FACE

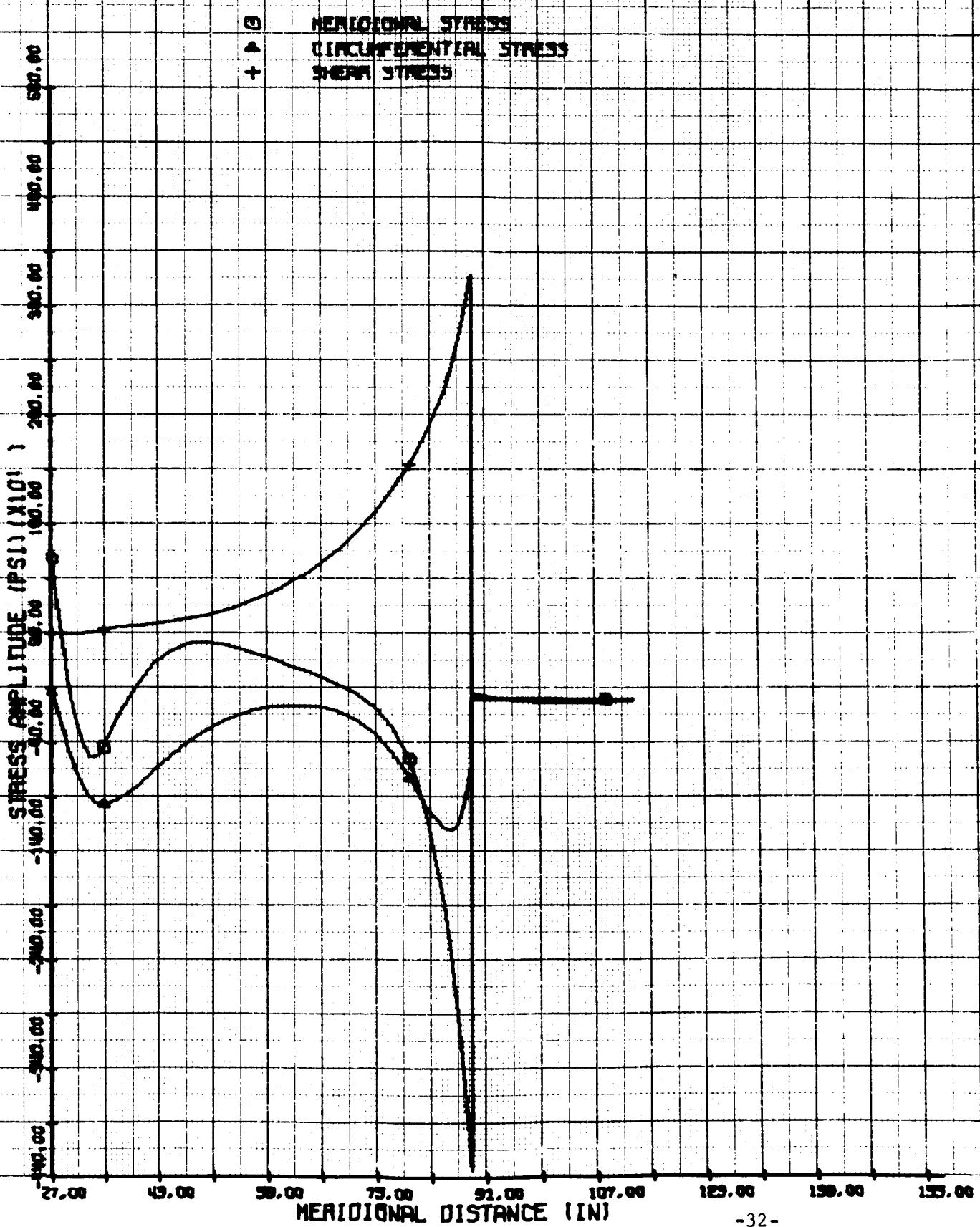


FIGURE 7B
SHELL STRESS AMPLITUDES
NASA TASK 3, CASE I (165 IN BASE). 5 G LATERAL ACCEL.
LAYER NO. 3, OUTER FACE

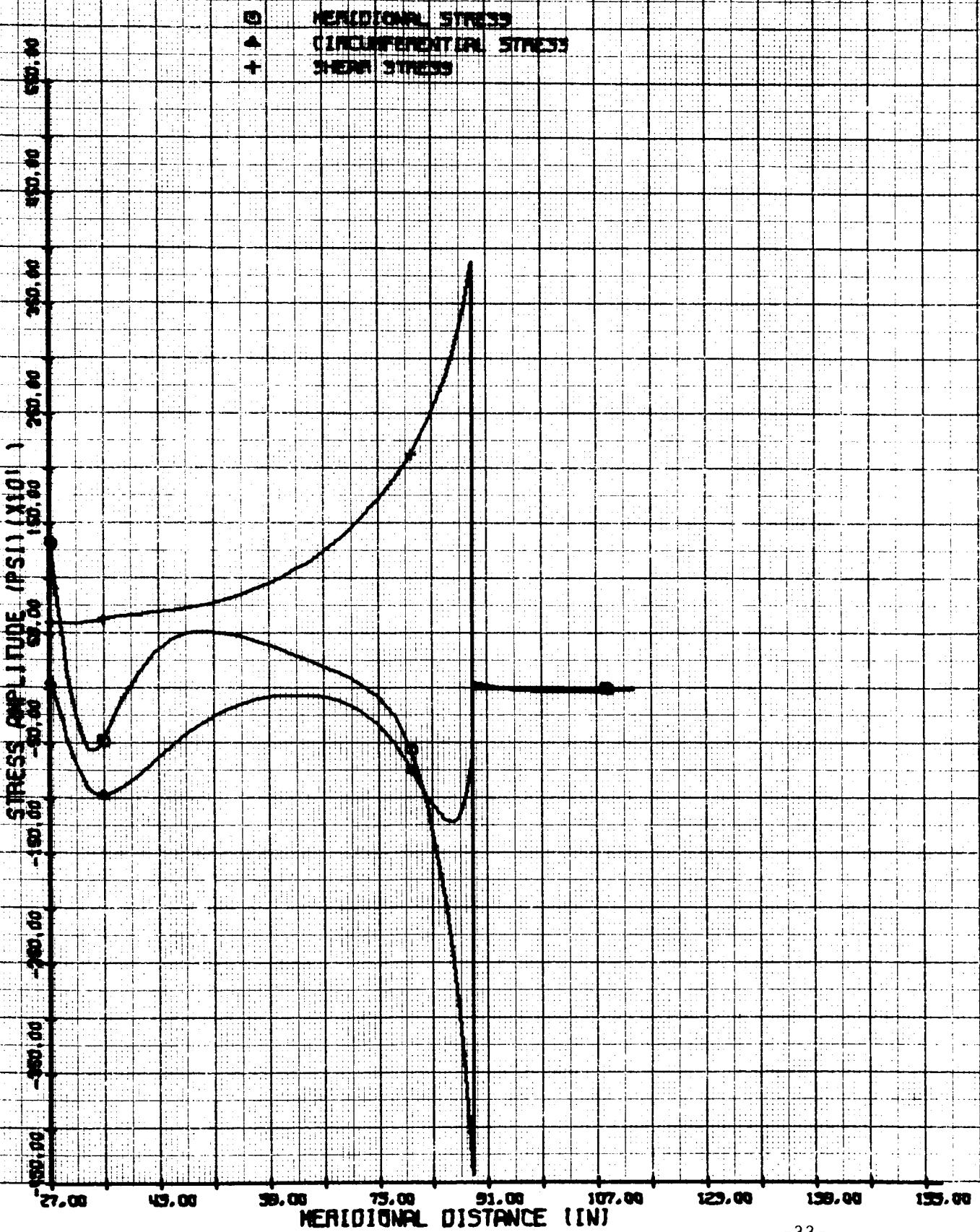


FIGURE 8a
MAXIMUM SHELL STRESSES
NASA TASK 3. CASE II CAPSULE SHELL
LAYER NO. 1. INNER FACE

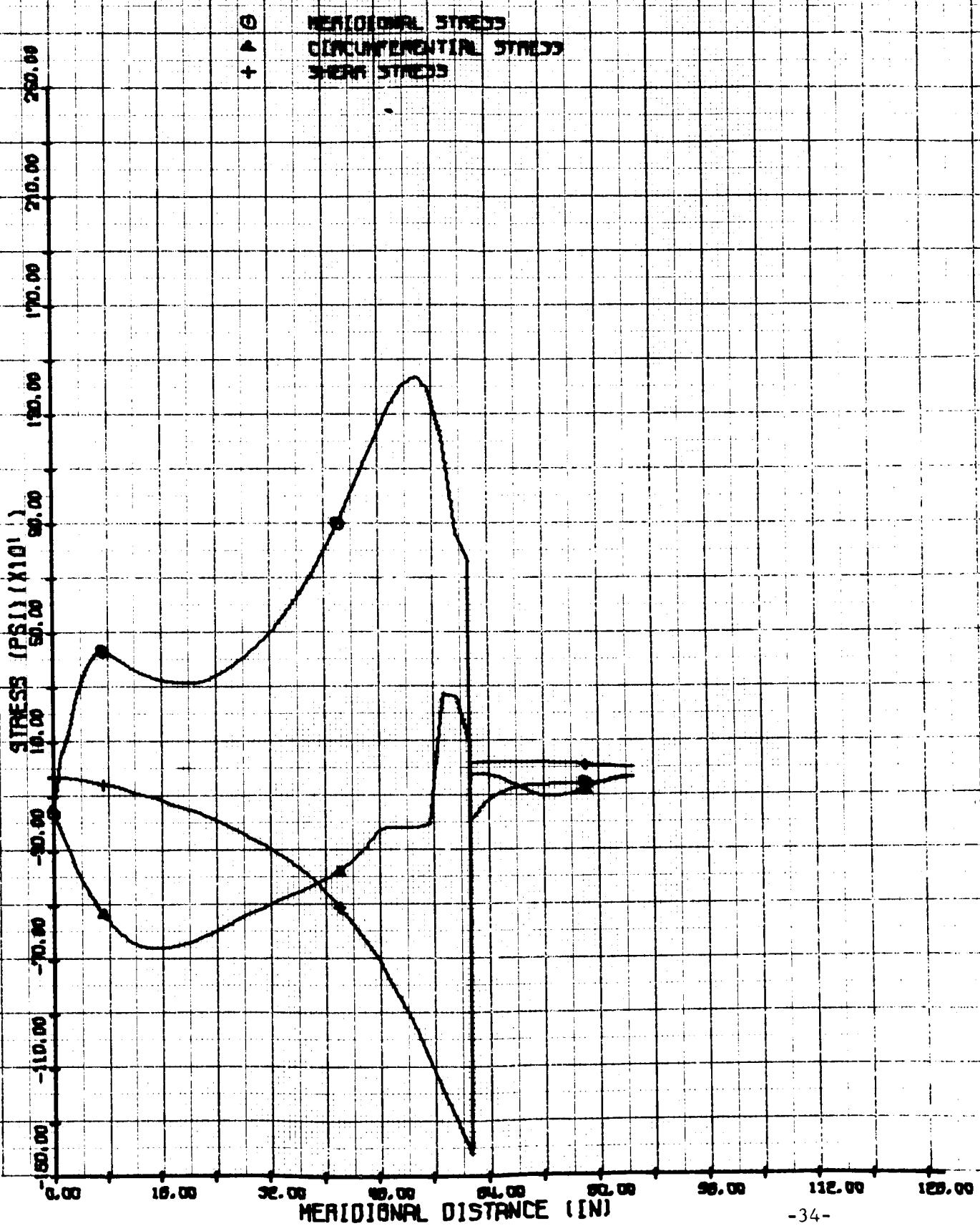


FIGURE 8b
MAXIMUM SHELL STRESSES
NASA TASK 3. CASE 11 CAPSULE SHELL
LAYER NO. 1. OUTER FACE

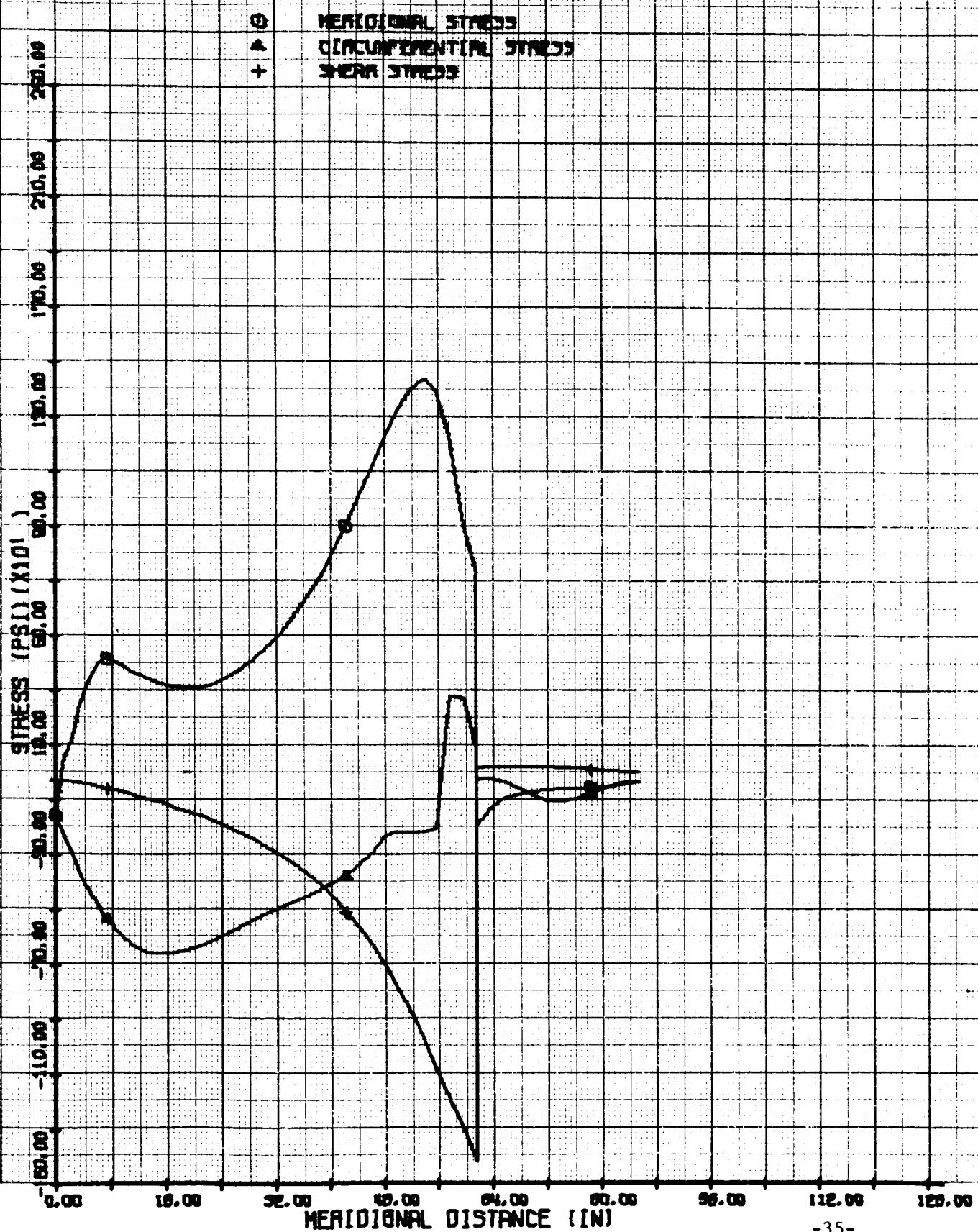
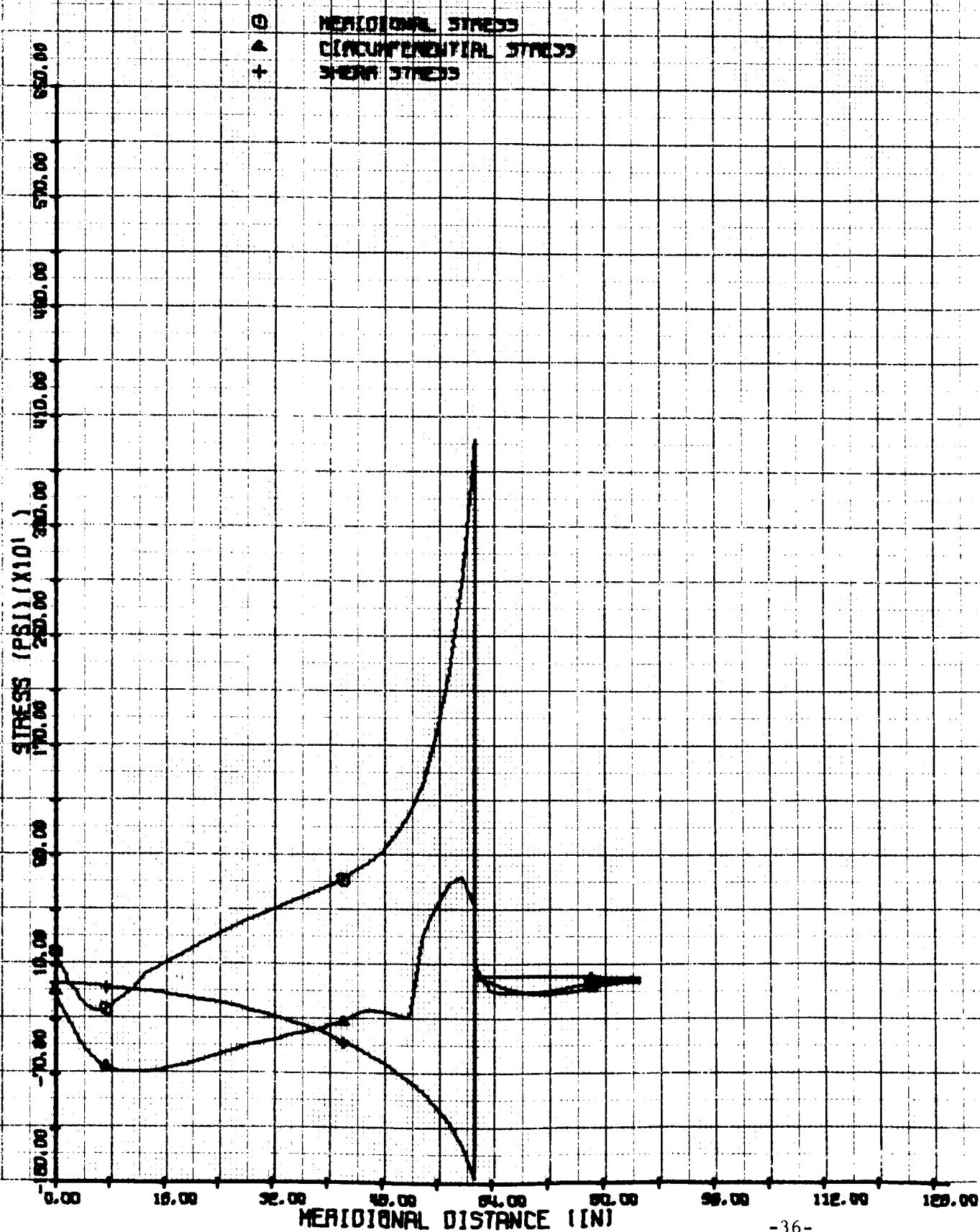


FIGURE 8c

MAXIMUM SHELL STRESSES
NBSR TREK 3. CRSE II CAPSULE SHELL
LAYER NO. 3. INNER FACE



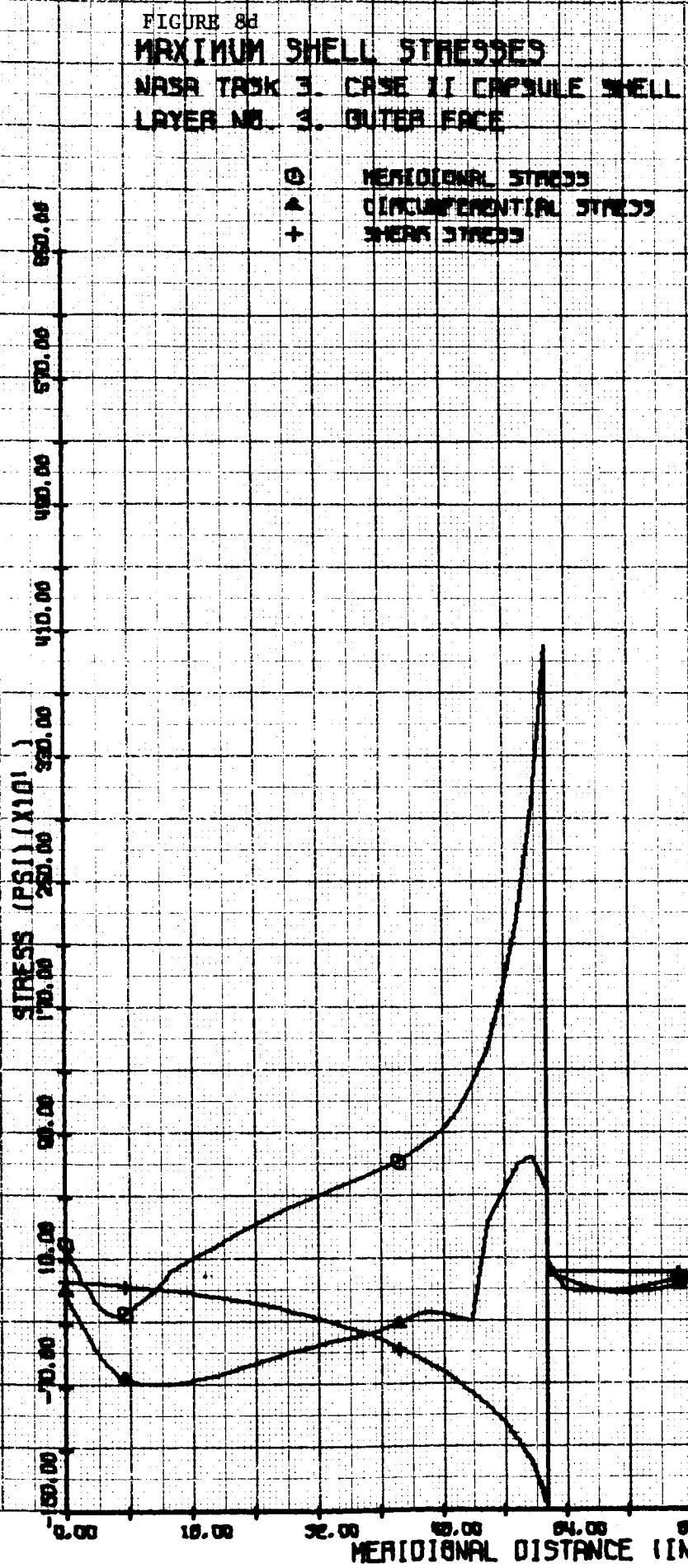


FIGURE 9a

SHELL STRESS AMPLITUDES

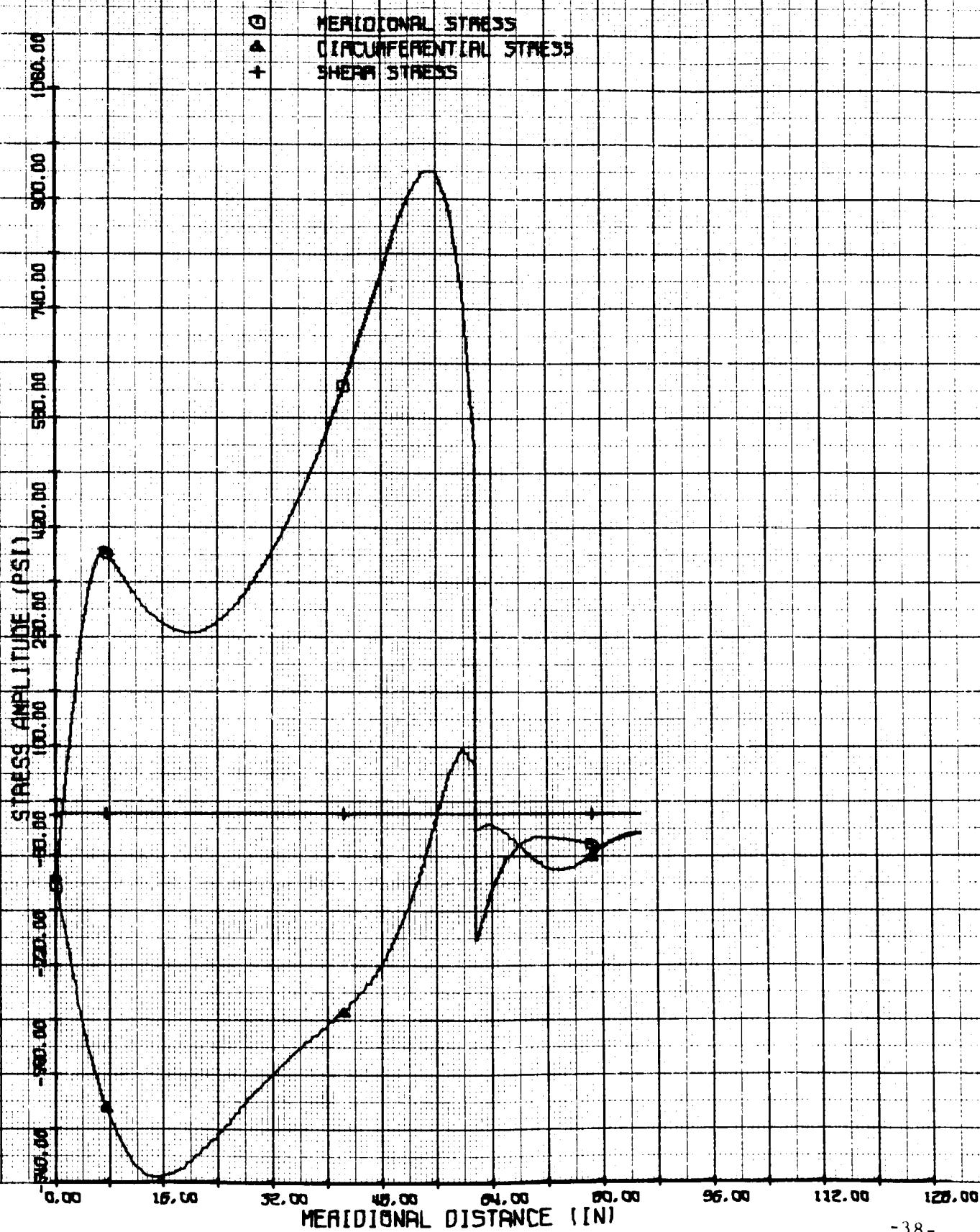
NASA TASK 3, CASE II, CAPSULE SHELL, 10G AXIAL ACCEL.
LAYER NO. 1, INNER FACE

FIGURE 96

SHELL STRESS AMPLITUDES

NASA TASK 3. CASE II. CAPSULE SHELL. 10G AXIAL ACCEL.
LAYER NO. 1. OUTER FACE

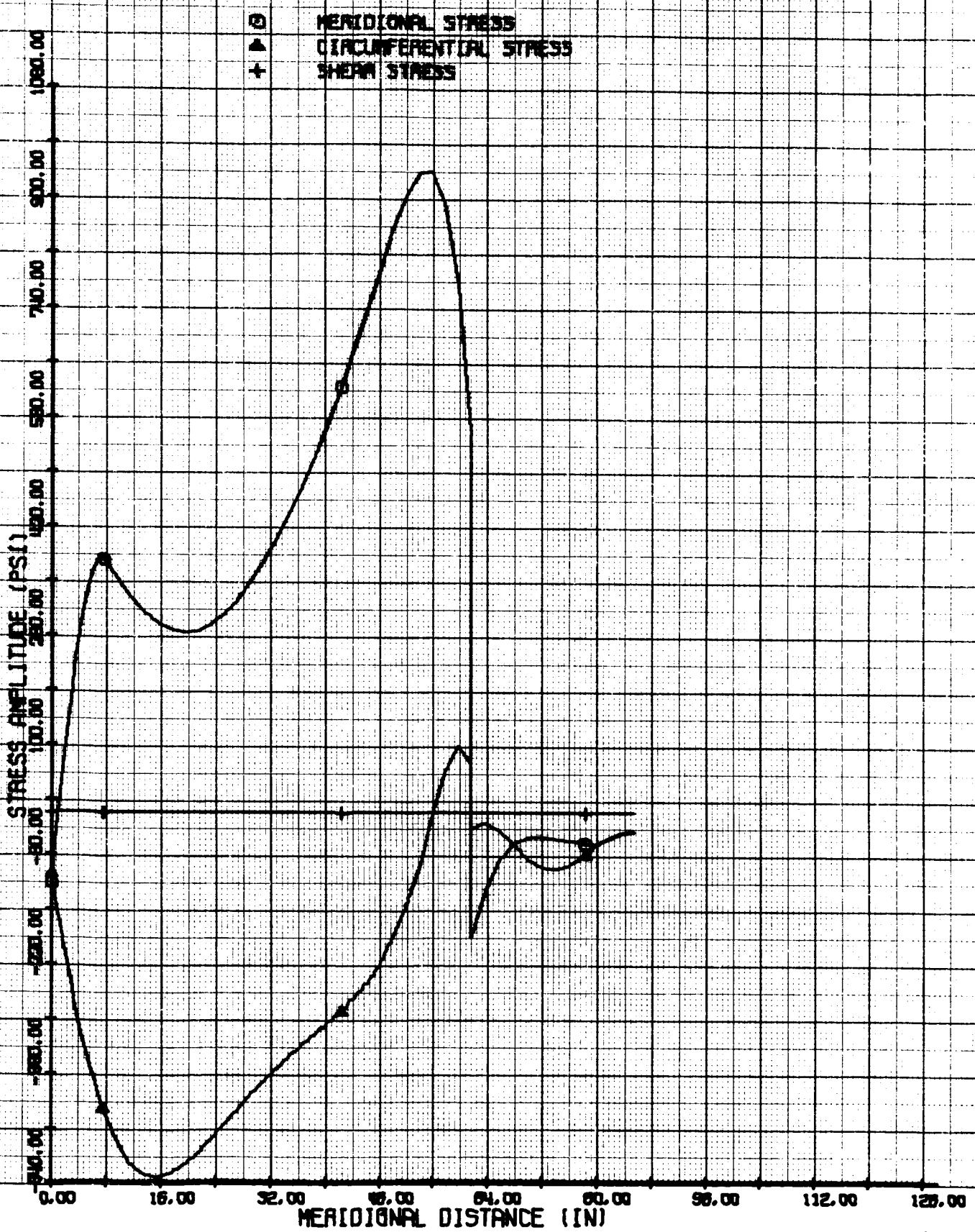


FIGURE 9c

SHELL STRESS AMPLITUDES

NASA TASK 3. CASE II. CAPSULE SHELL. 10G AXIAL ACCEL.

LAYER NO. 3. INNER FACE

- MERIDIONAL STRESS
- ▲ CIRCUMFERENTIAL STRESS
- + SHEAR STRESS

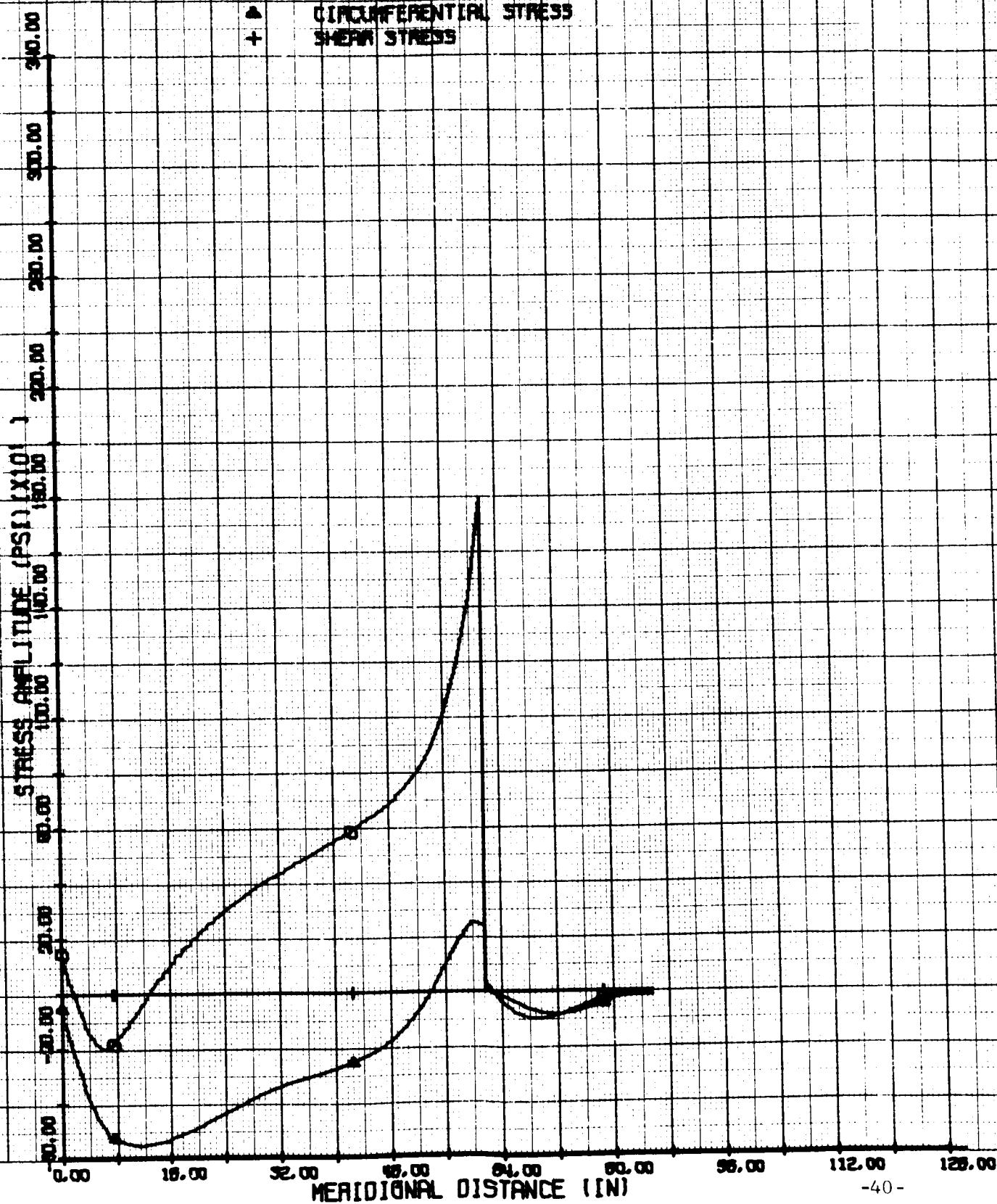


FIGURE 9d

SHELL STRESS AMPLITUDES

NASA TASK 3. CASE II. CAPSULE SHELL. 10G AXIAL ACCEL.

LAYER NO. 3. OUTER FACE

- MERIDIONAL STRESS
- ▲ CIRCUMFERENTIAL STRESS
- + SHERW STRESS

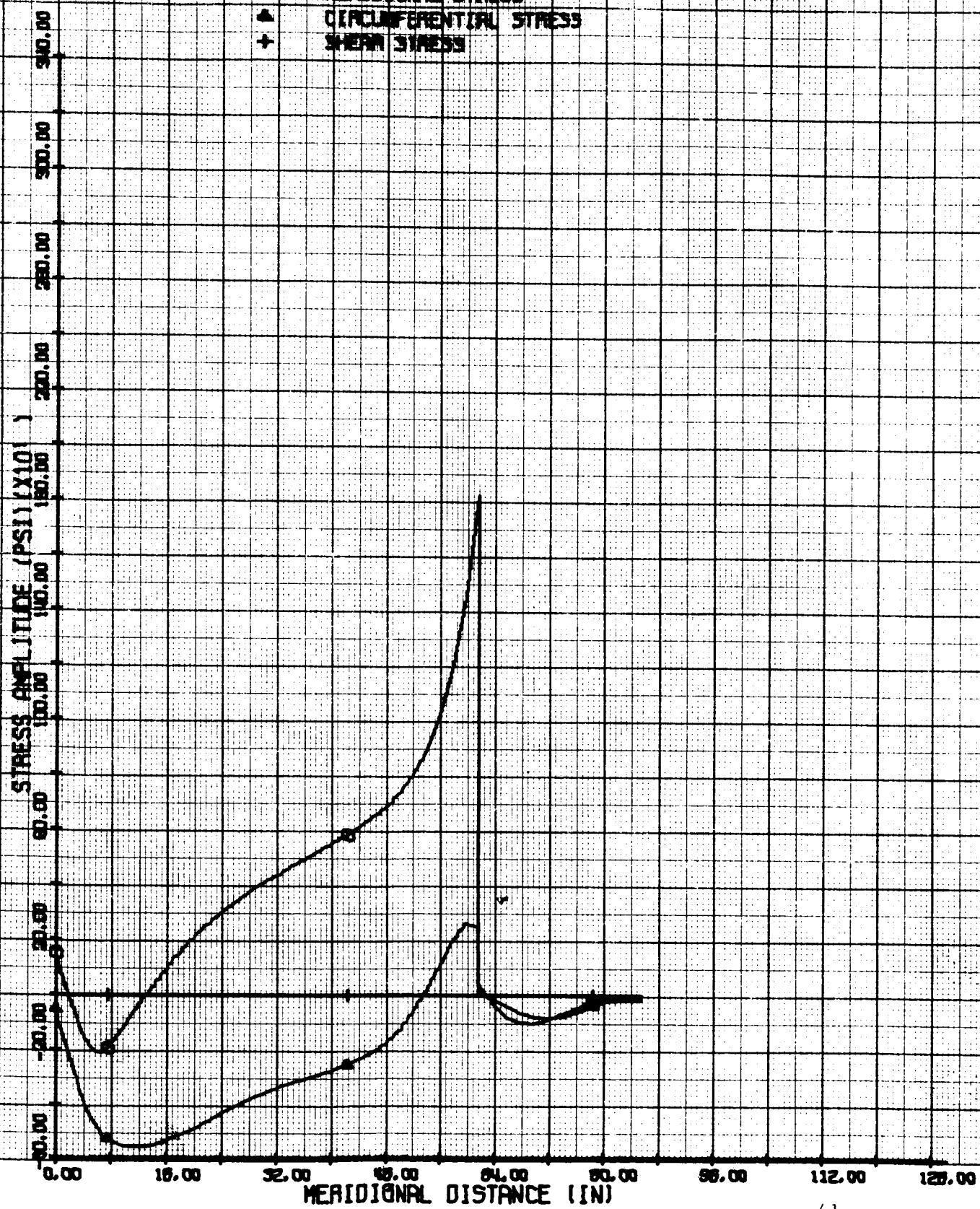


FIGURE 10a
SHELL STRESS AMPLITUDES
NASA TASK 3. CASE II CAPSULE SHELL. 5 G LATERAL ACCEL
LAYER NO. 1. INNER FACE

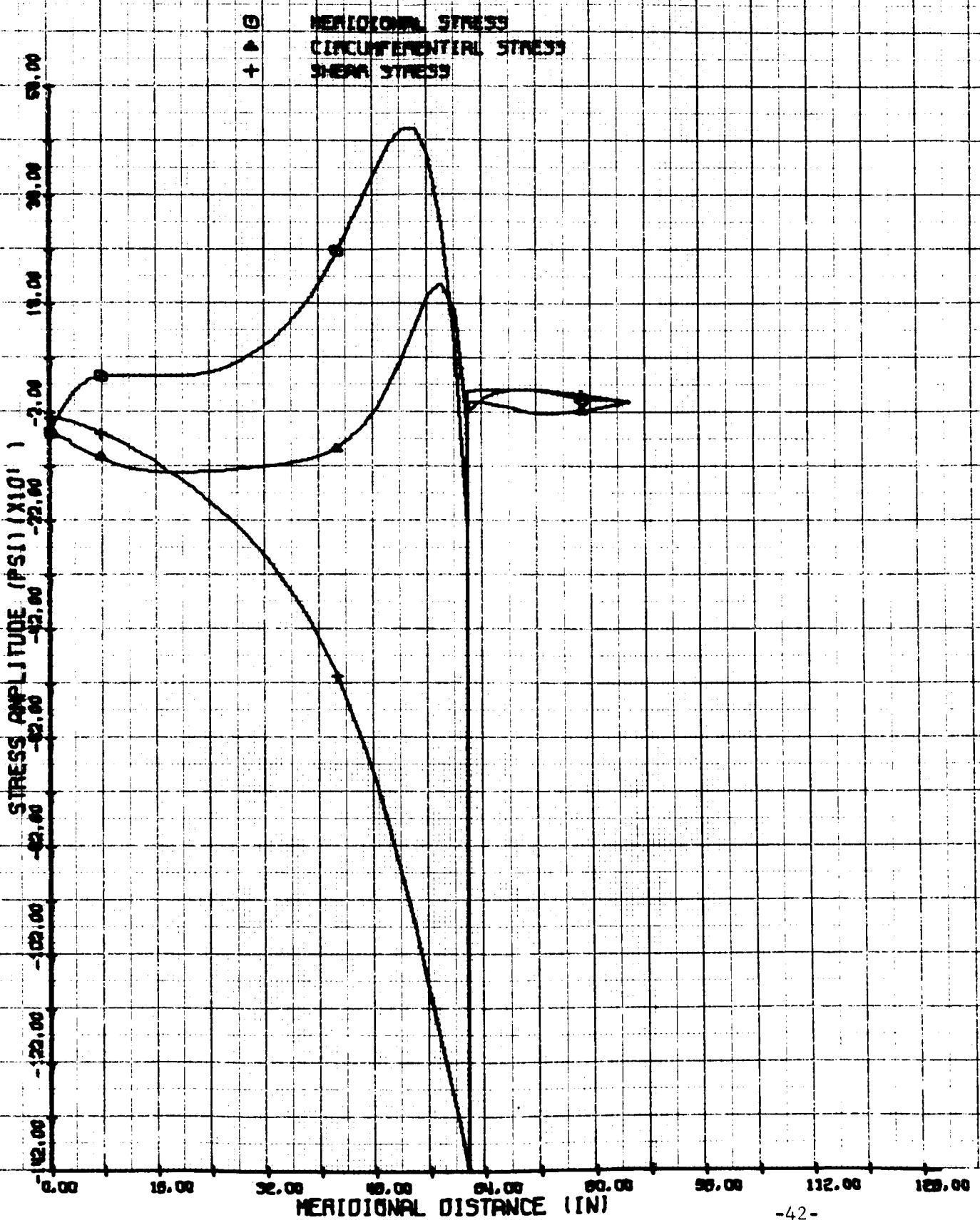


FIGURE 10b
SHELL STRESS AMPLITUDES

NASA TASK 3. CASE II CAPSULE SHELL. 5 G LATERAL ACCEL.
LAYER NO. 1. OUTER FACE

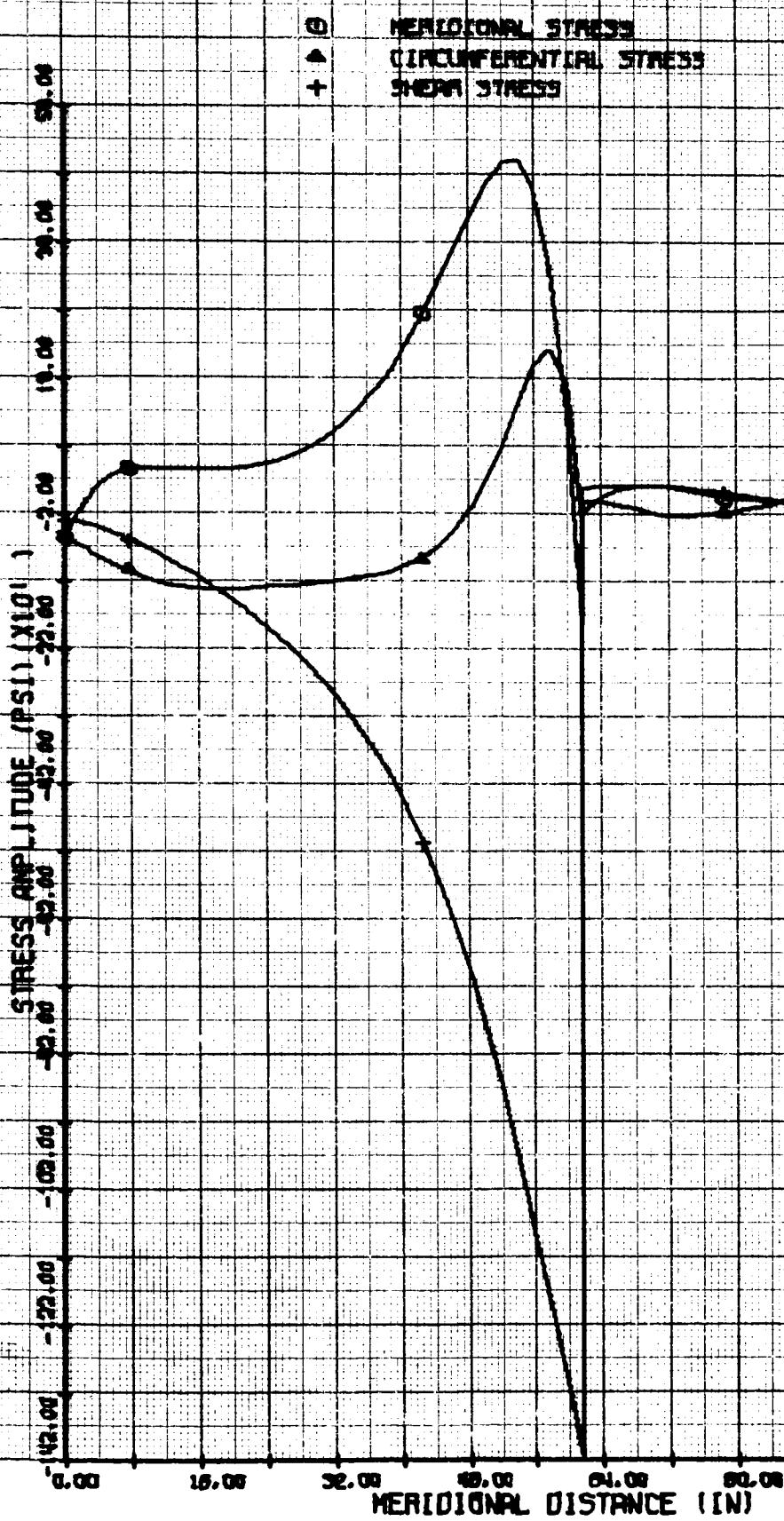


FIGURE 10c

SHELL STRESS AMPLITUDES
NASA TASK 3. CASE II CAPSULE SHELL. 5 G LATERAL ACCEL.
LAYER NO. 3. INNER FORCE

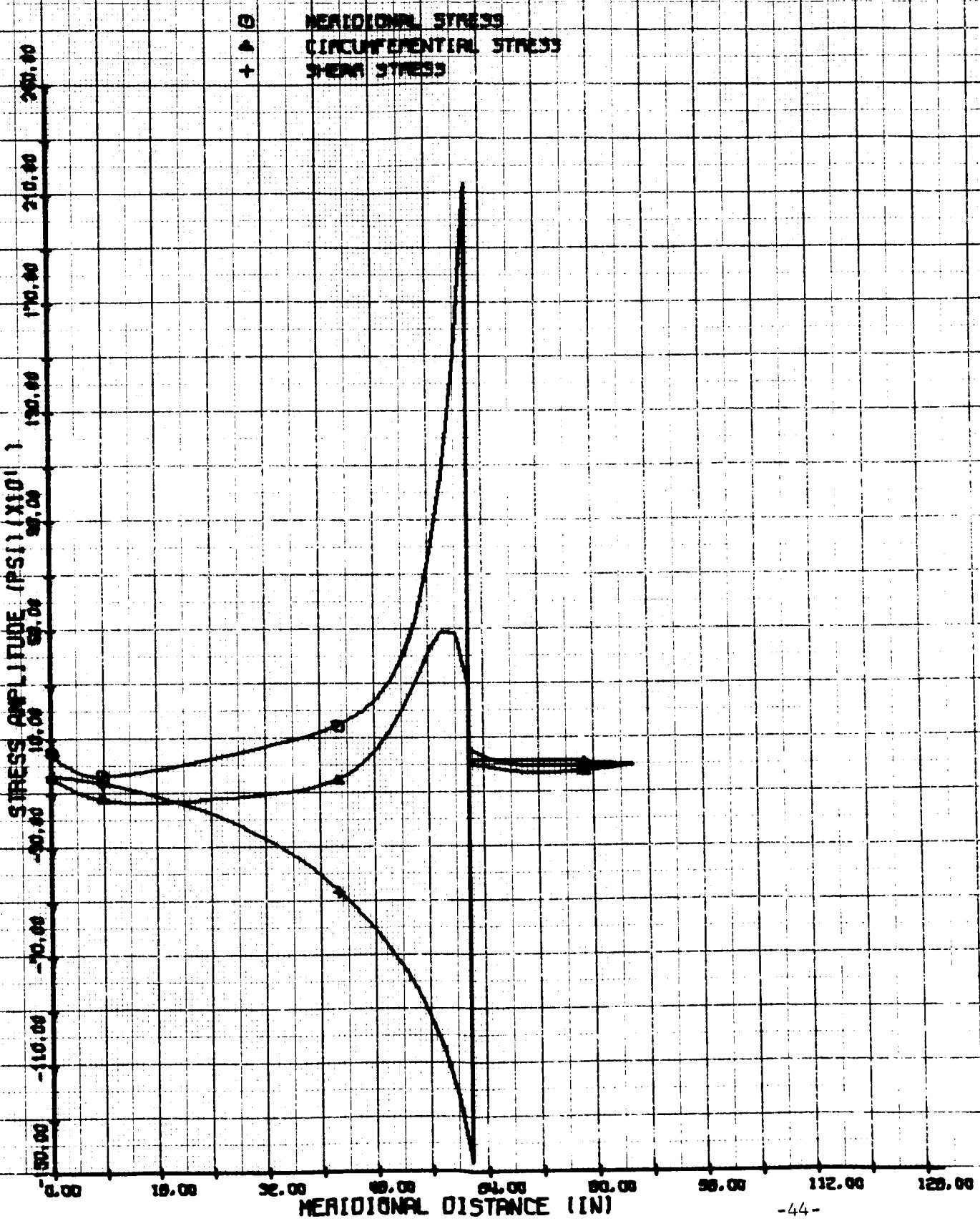


FIGURE 10d

SHELL STRESS AMPLITUDES

NASA TASK 3. CASE II CAPSULE SHELL. 5 G LATERAL ACCEL.
LAYER NO. 3. OUTER FACE

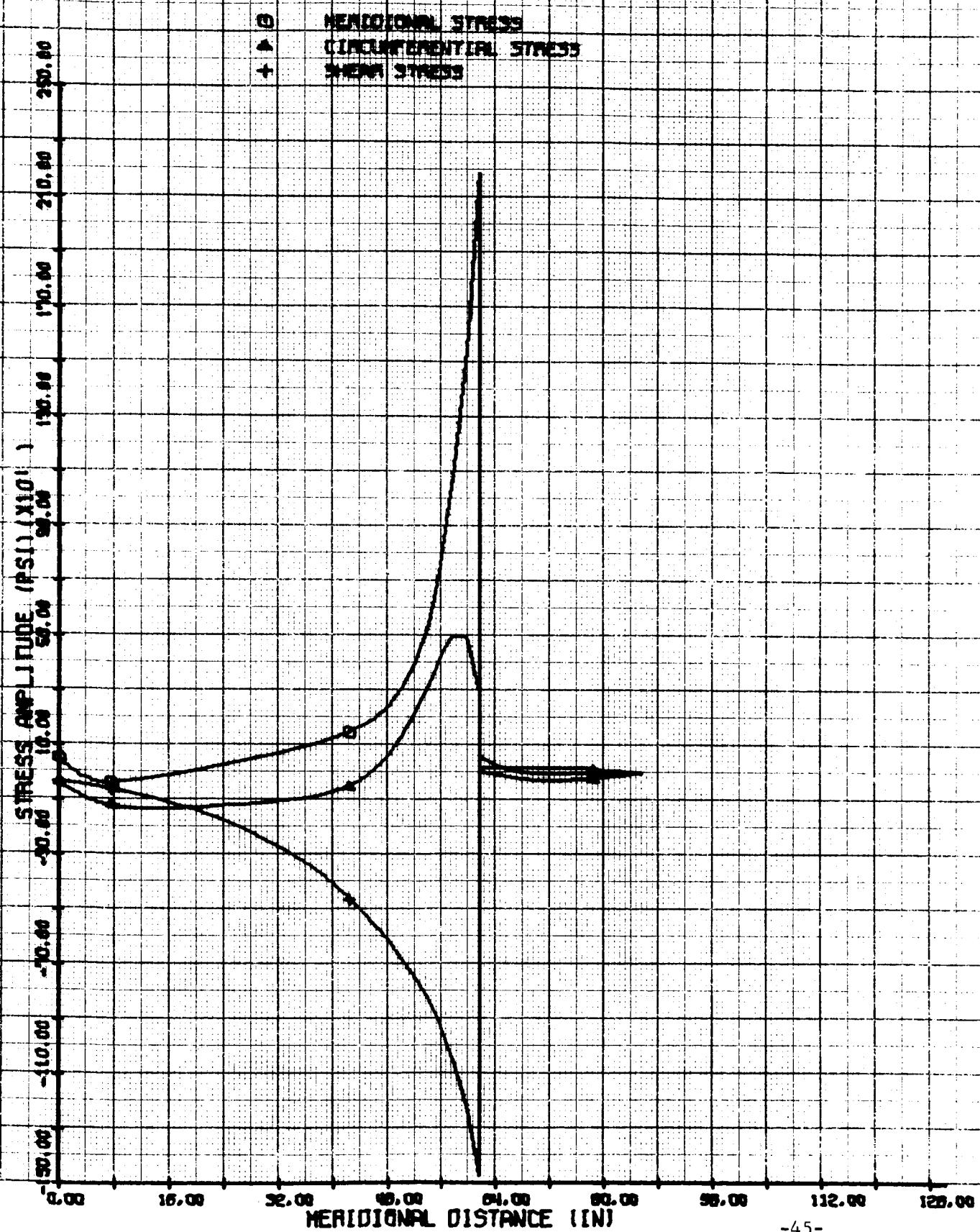


FIGURE 11a
MAXIMUM SHELL STRESSES
TASK 3. CASE II RAPTOR SHELL [120 IN BASE]
LAYER NO. 1. INNER FACE

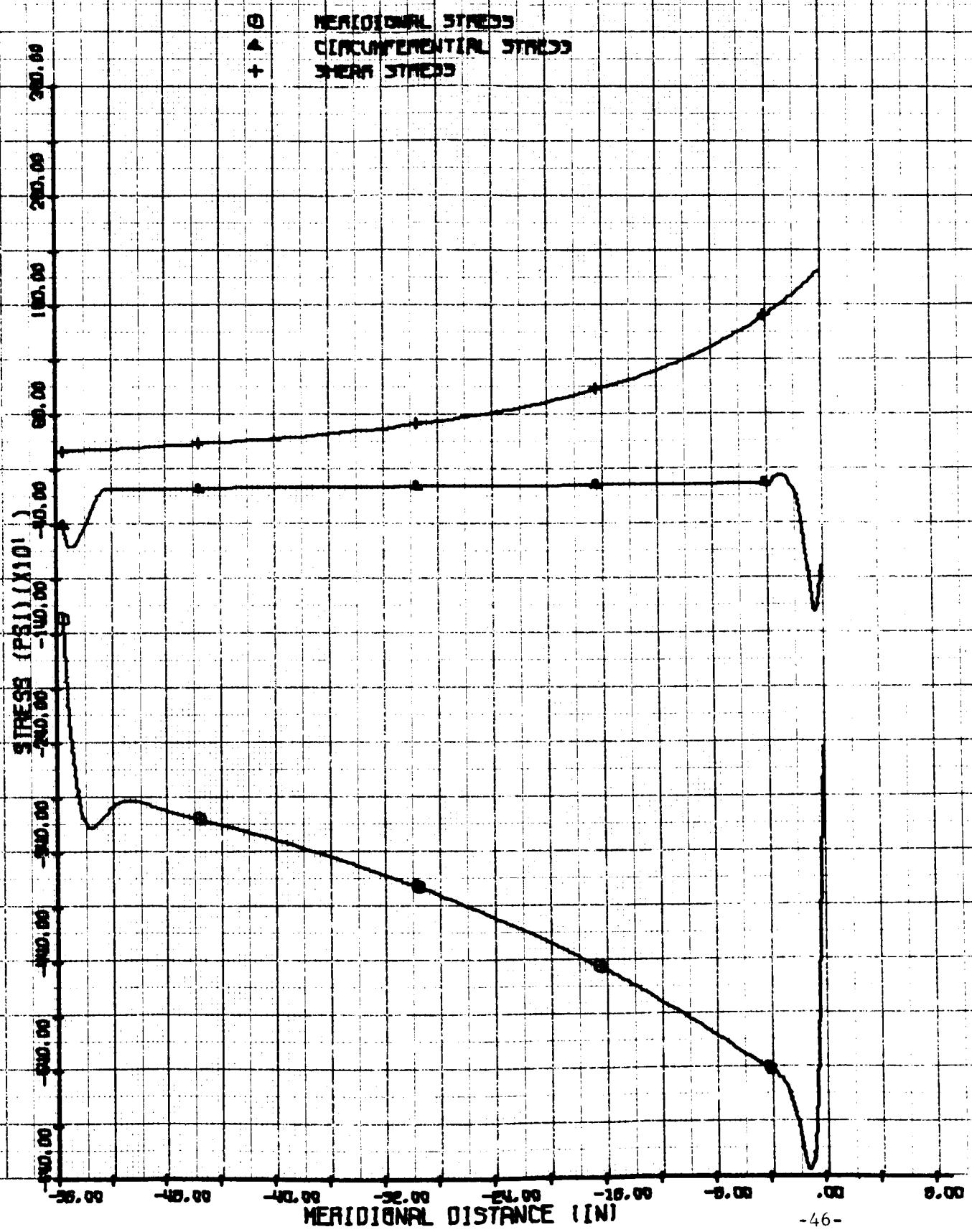


FIGURE 11b
MAXIMUM SHELL STRESSES
TASK 3. CASE 11 ADAMSON SHELL (120 IN DIAM)
LAYER NO. 1. OUTER FACE

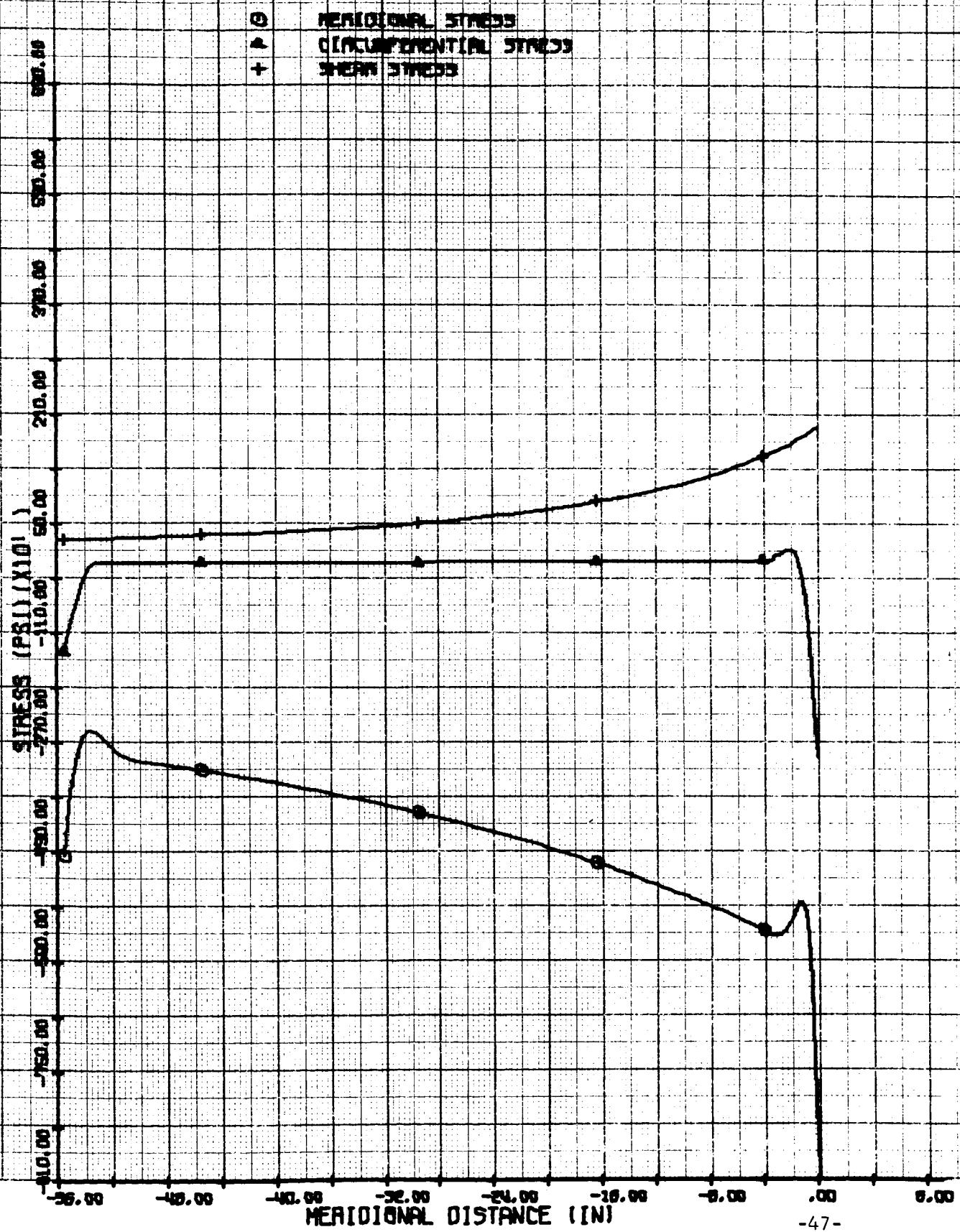


FIGURE 12a

SHELL STRESS AMPLITUDES

**TASK 3. CRSE 11 ADROPTOR SHELL [120 IN BASED 10 G AXIAL ACCEL
LAYER NO. 1. INNER FACE**

- MERIDIONAL STRESS
- ▲ CIRCUMFERENTIAL STRESS
- + SHEAR STRESS

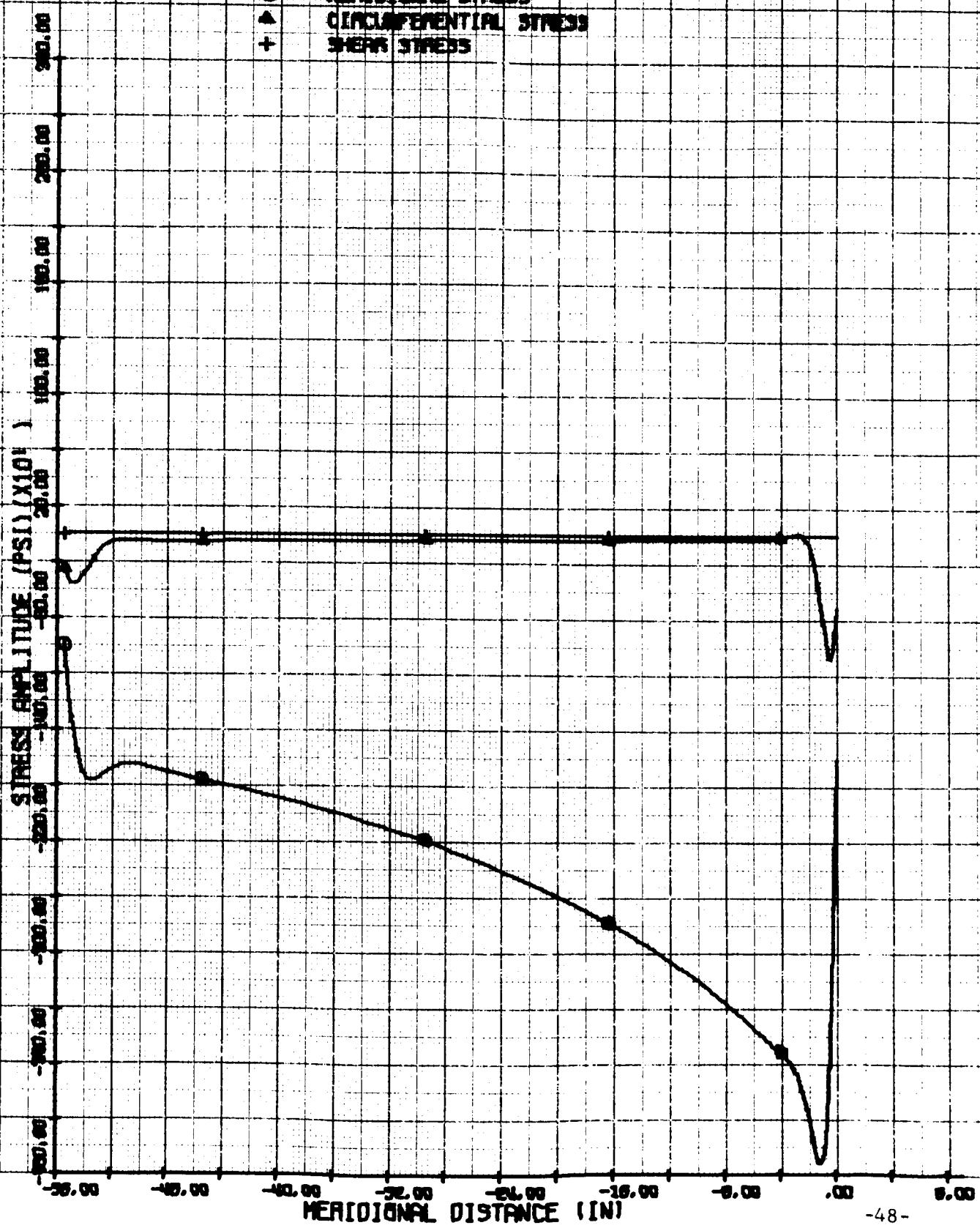


FIGURE 12b

SHELL STRESS AMPLITUDES

TASK 3. CASE II ROTATOR SHELL (120 IN BASED) 10 G AXIAL ACCEL
LAYER NO. 1. OUTER FACE

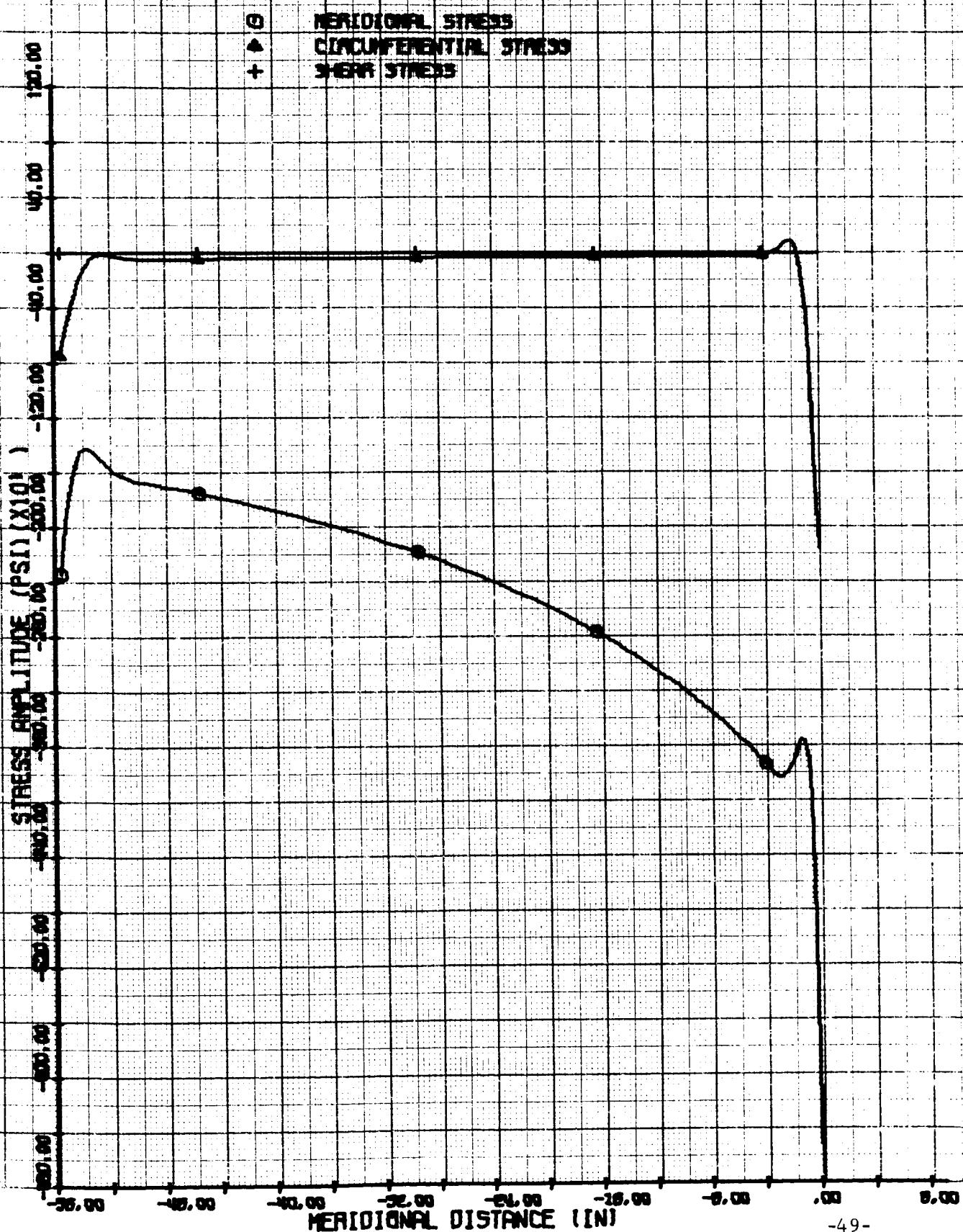


FIGURE 13a

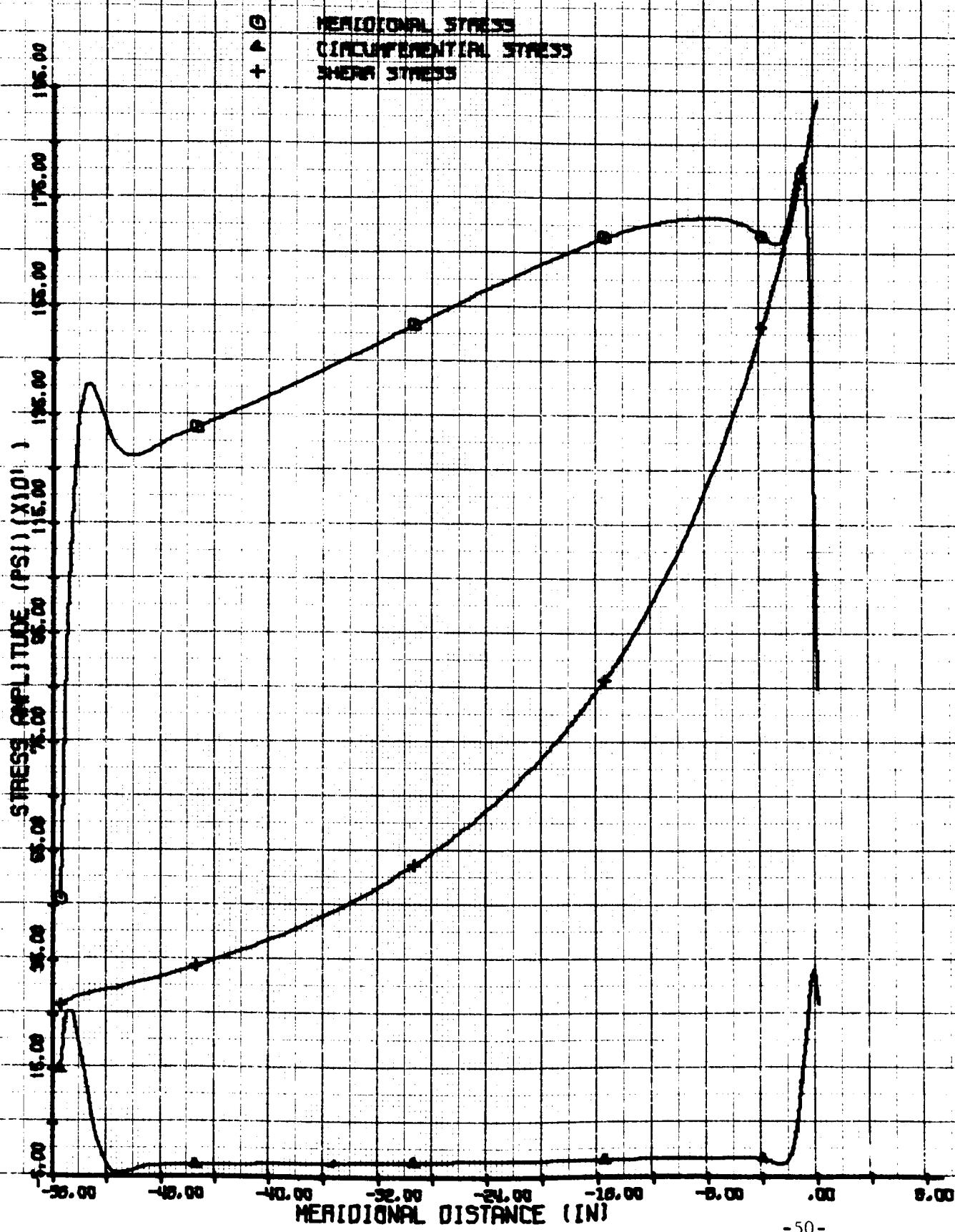
SHELL STRESS AMPLITUDESTASK 3. CASE II RORPTOR SHELL [120 IN BASE] 5G LATERAL ACCEL
LAYER NO. 1. INNER FACE

FIGURE 13b
SHELL STRESS AMPLITUDES
TASK 3. CASE II ROMPTOR SHELL 1120 IN BASEI SG LATERAL ACCEL
LAYER NO. 1. OUTER FACE

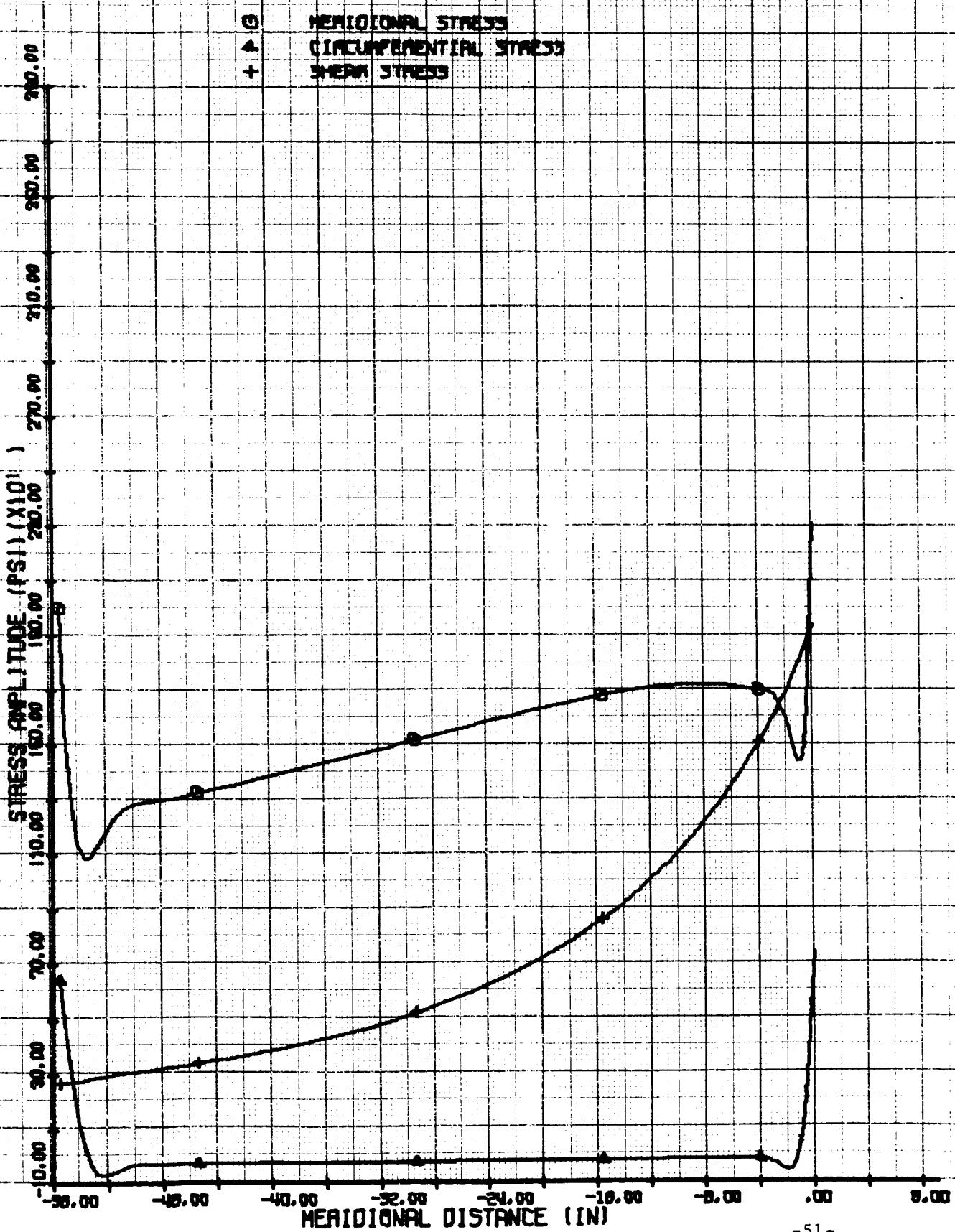


FIGURE 14a

MAXIMUM SHELL STRESSES

TASK 3. CASE II ROTOR SHELL (165 IN BASE)

LAYER NO. 1. INNER FACE

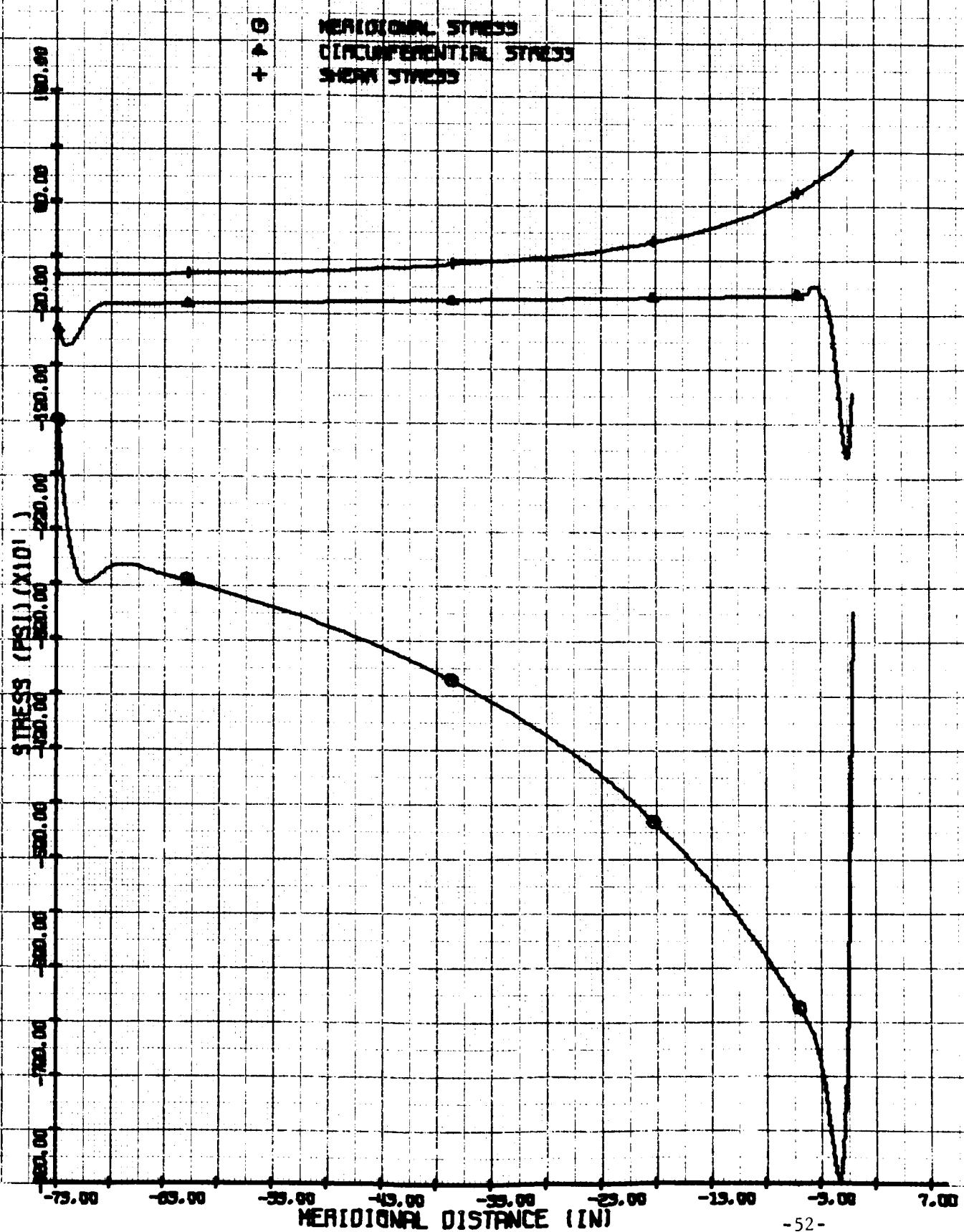


FIGURE 14b

MAXIMUM SHELL STRESSES

TASK 3. CASE 11 PORPORT SHELL (165 IN BASED)
LAYER NO. 1. OUTER FACE

- MERIDIONAL STRESS
- ▲ CIRCUMFERENTIAL STRESS
- + NORMAL STRESS

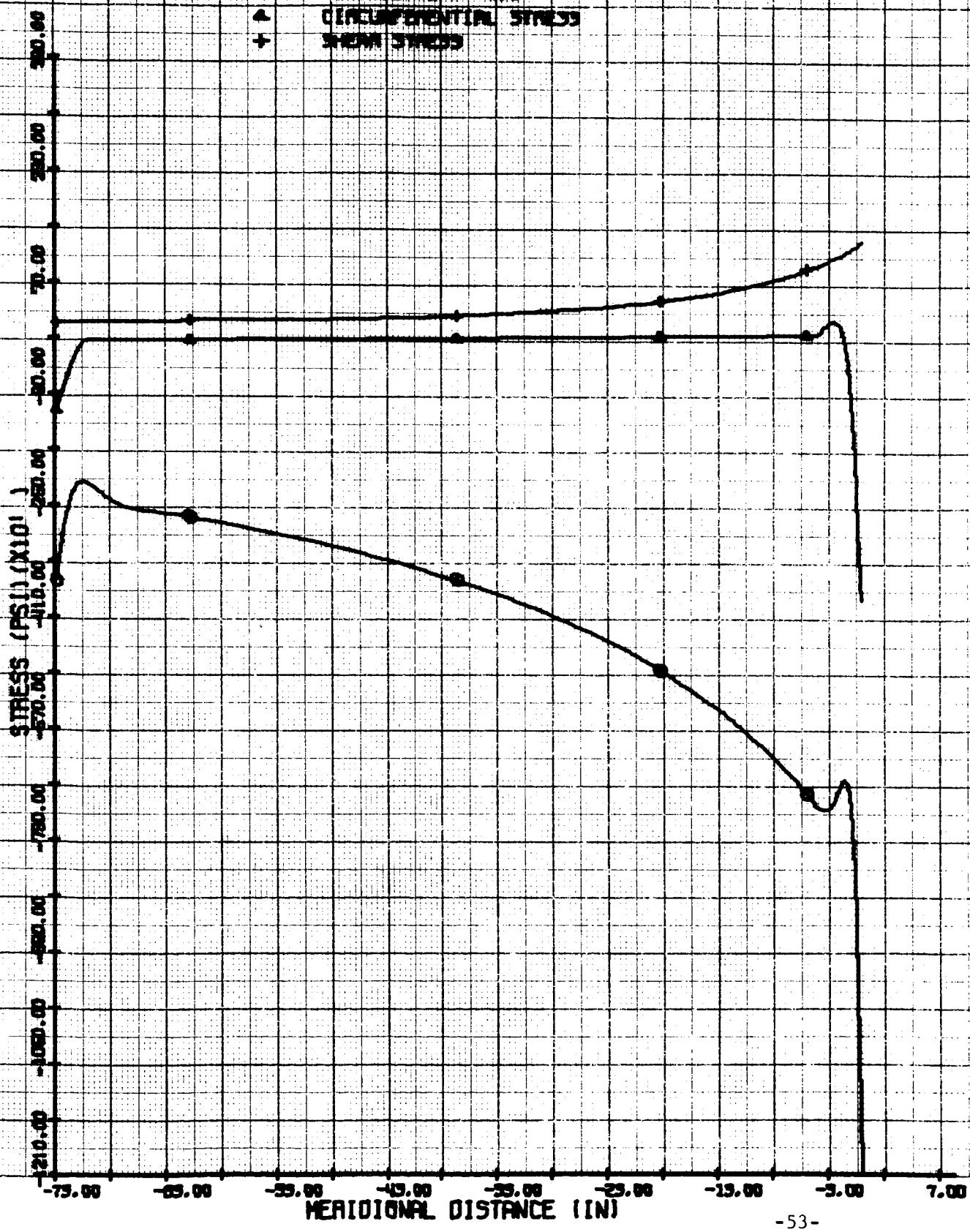


FIGURE 15a

SHELL STRESS AMPLITUDES

TASK 3. CASE II ADAPTER SHELL [165 IN BASE] 10 G AXIAL ACCEL
LAYER NO. 1. INNER FACE

- MERIDIONAL STRESS
- ▲ CIRCUMFERENTIAL STRESS
- + SHEAR STRESS

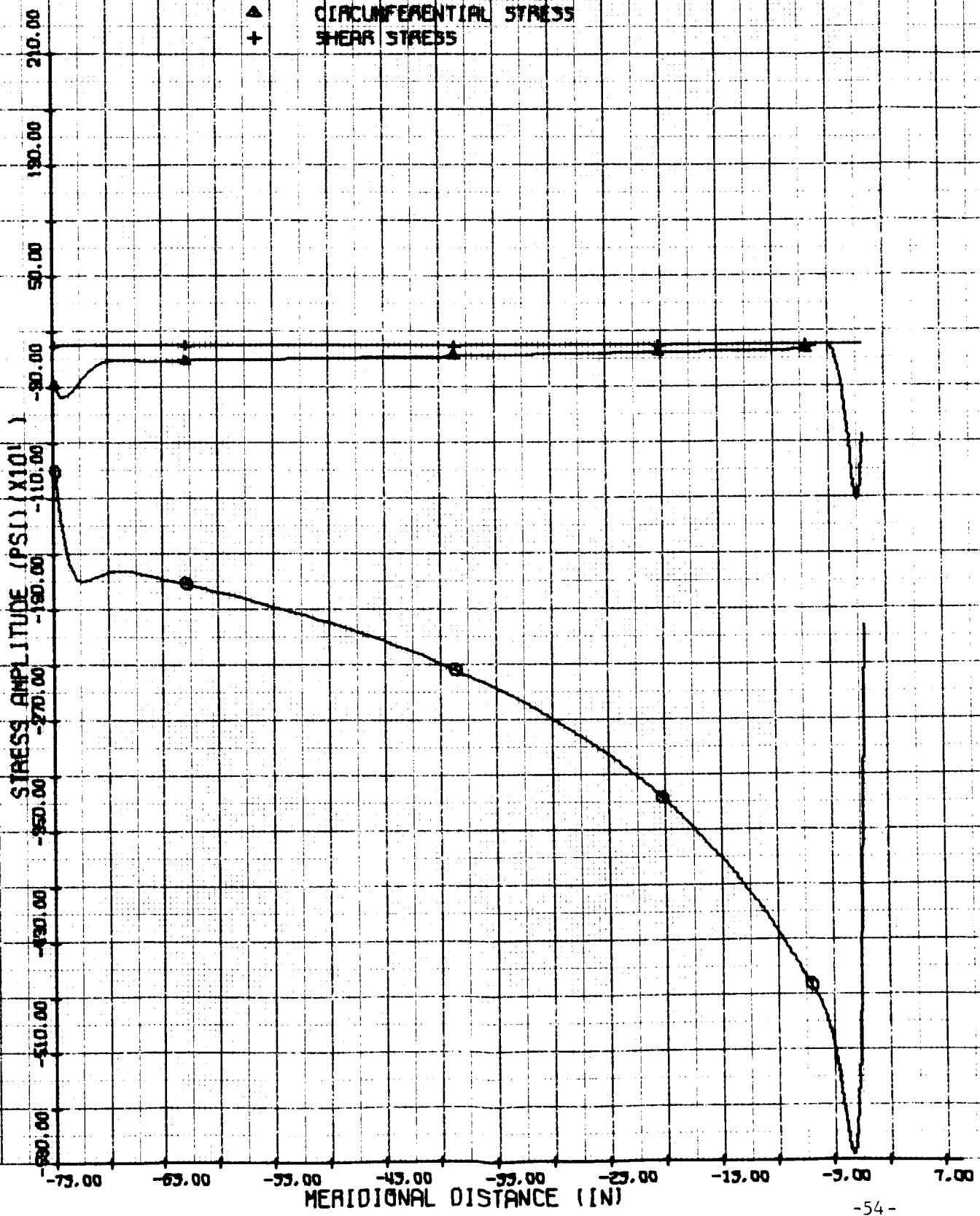


FIGURE 15b

SHELL STRESS AMPLITUDESTASK 3. CASE 11 ADAPTOR SHELL 116S IN BASE1 10 G AXIAL ACCEL
LAYER NO. 1. OUTER FACE

- (○) MERIDIONAL STRESS
- (▲) CIRCUMFERENTIAL STRESS
- (+) SHEAR STRESS

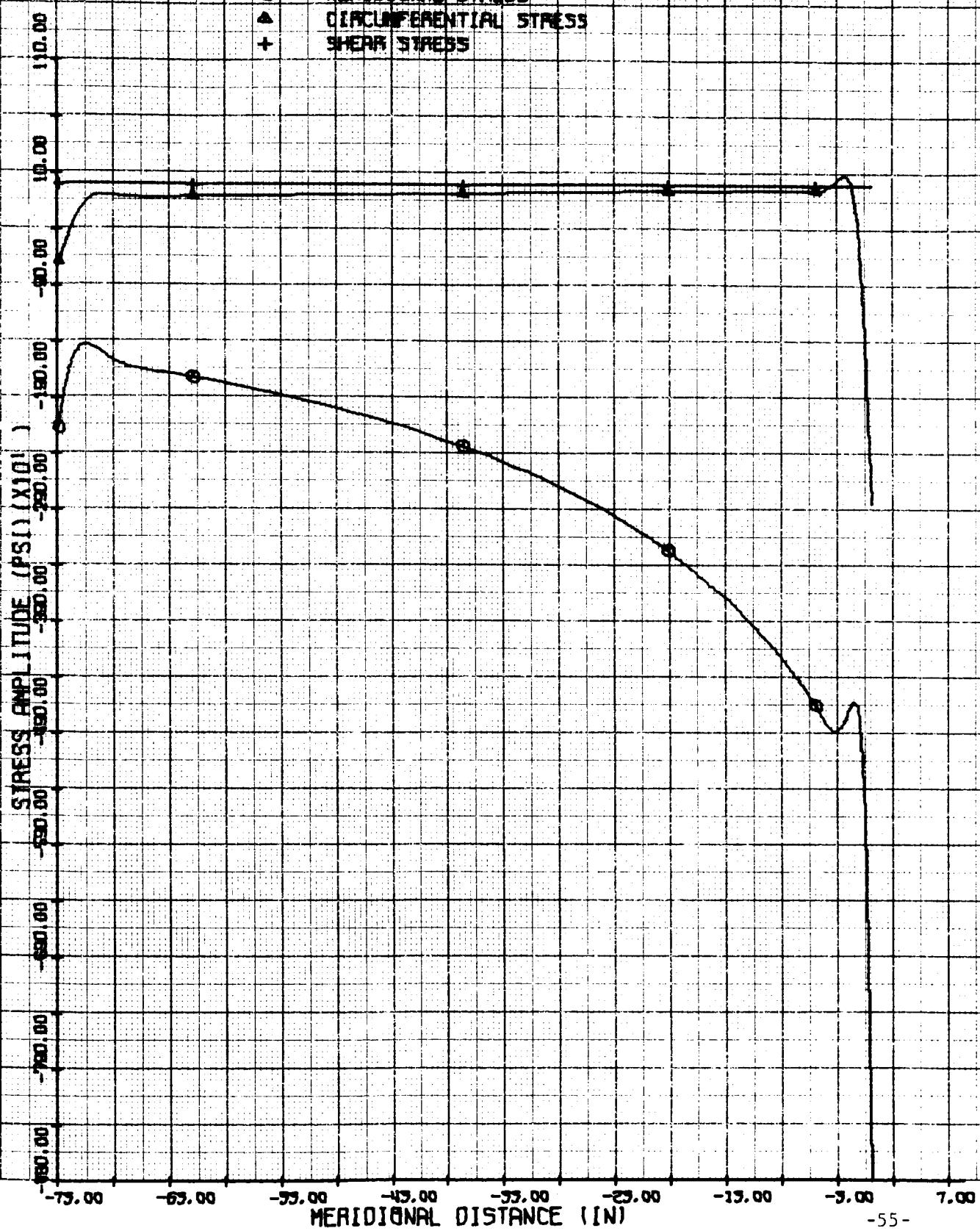


FIGURE 16a

SHELL STRESS AMPLITUDES

TASK 3. CASE II ROMPTOR SHELL (165 IN BASE) 5G LATERAL ACCEL
LAYER NO. 1. INNER FACE

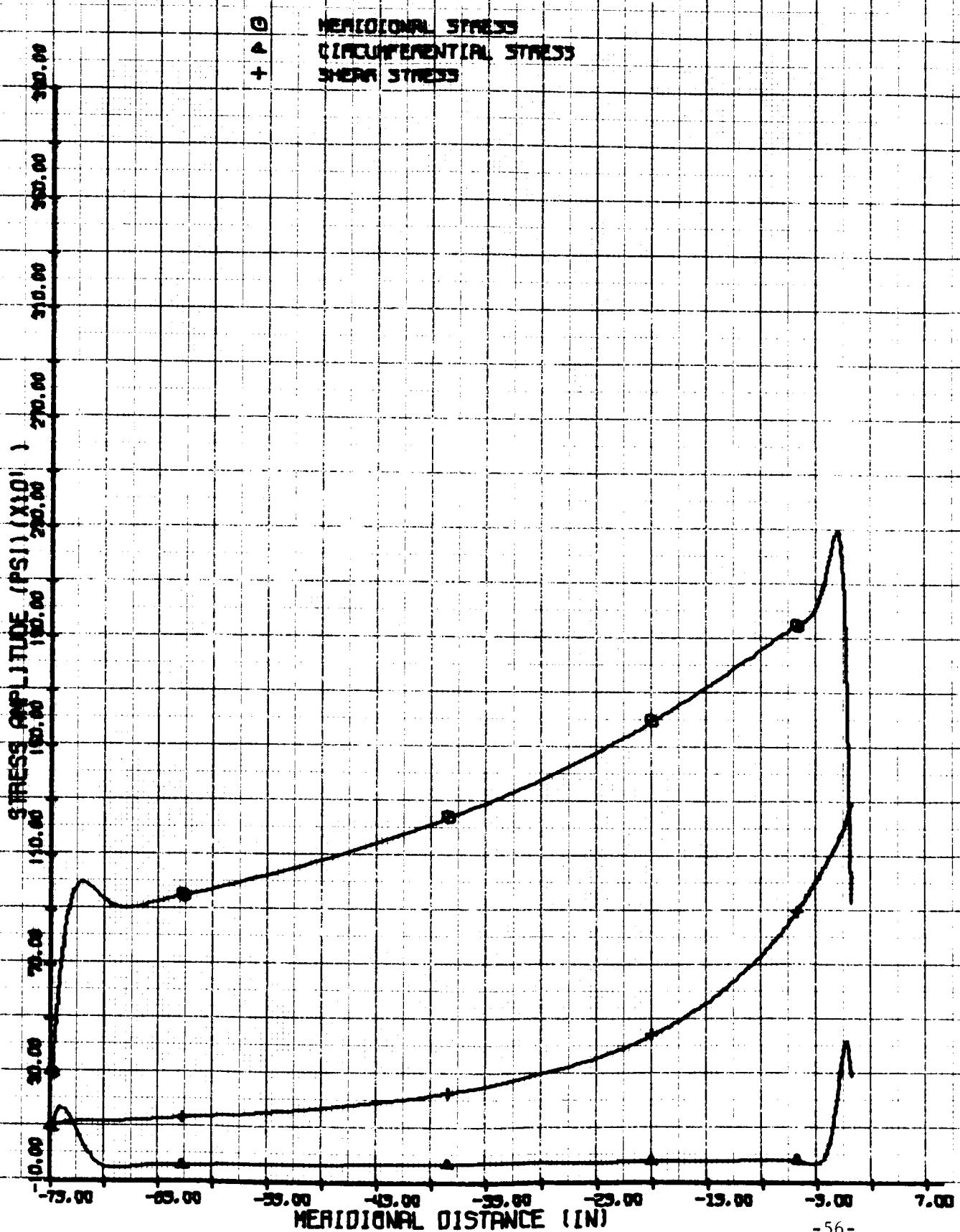


FIGURE 166

SHELL STRESS AMPLITUDES

TASK 3. CASE II ROMPTOR SHELL (165 IN BASE) SG LATERAL ACCEL
LAYER NO. 1. OUTER FACE

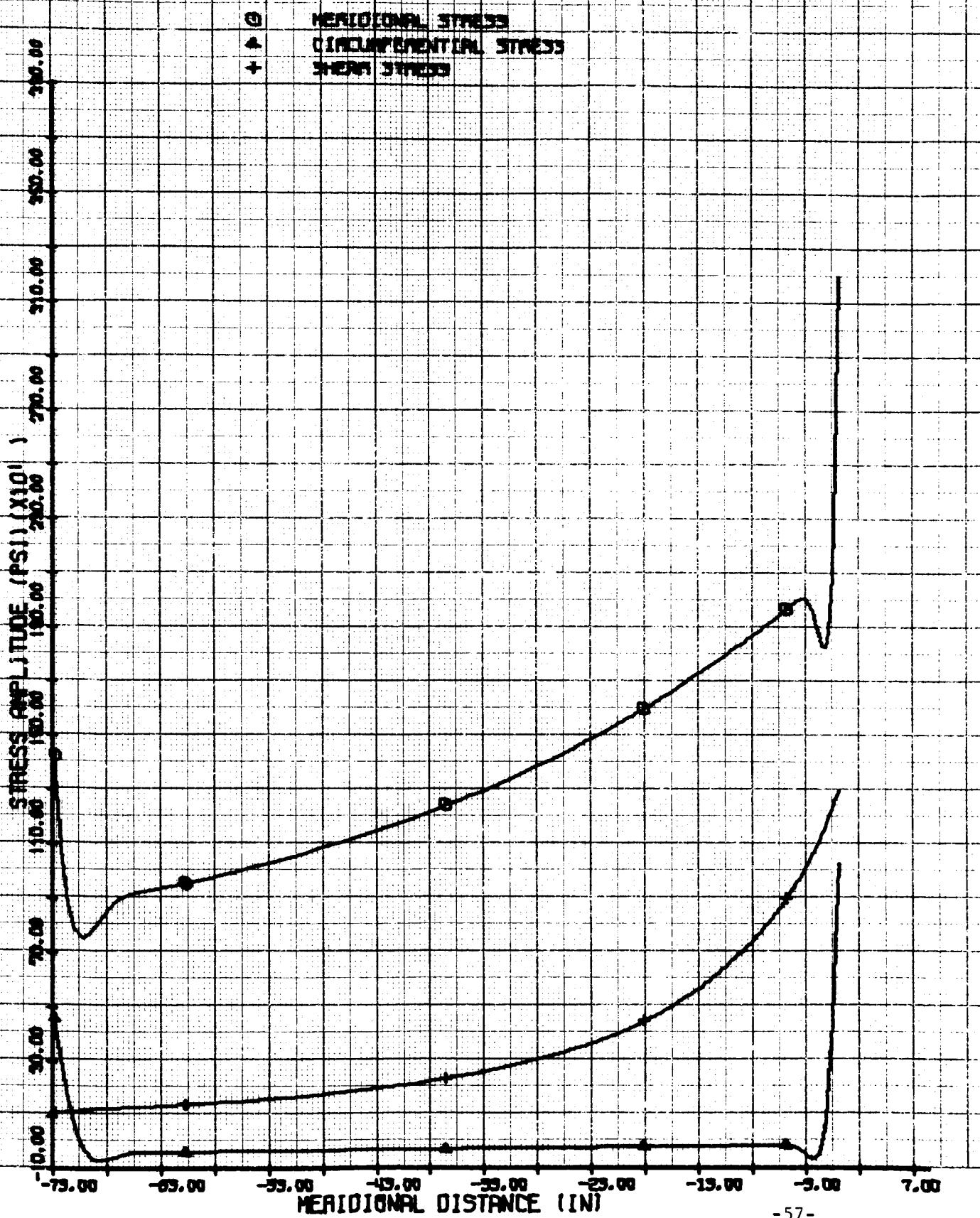


FIGURE 17a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE 1 (1120 IN BASE). OMEGA 1 = 17.07 CPS (IN=0)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

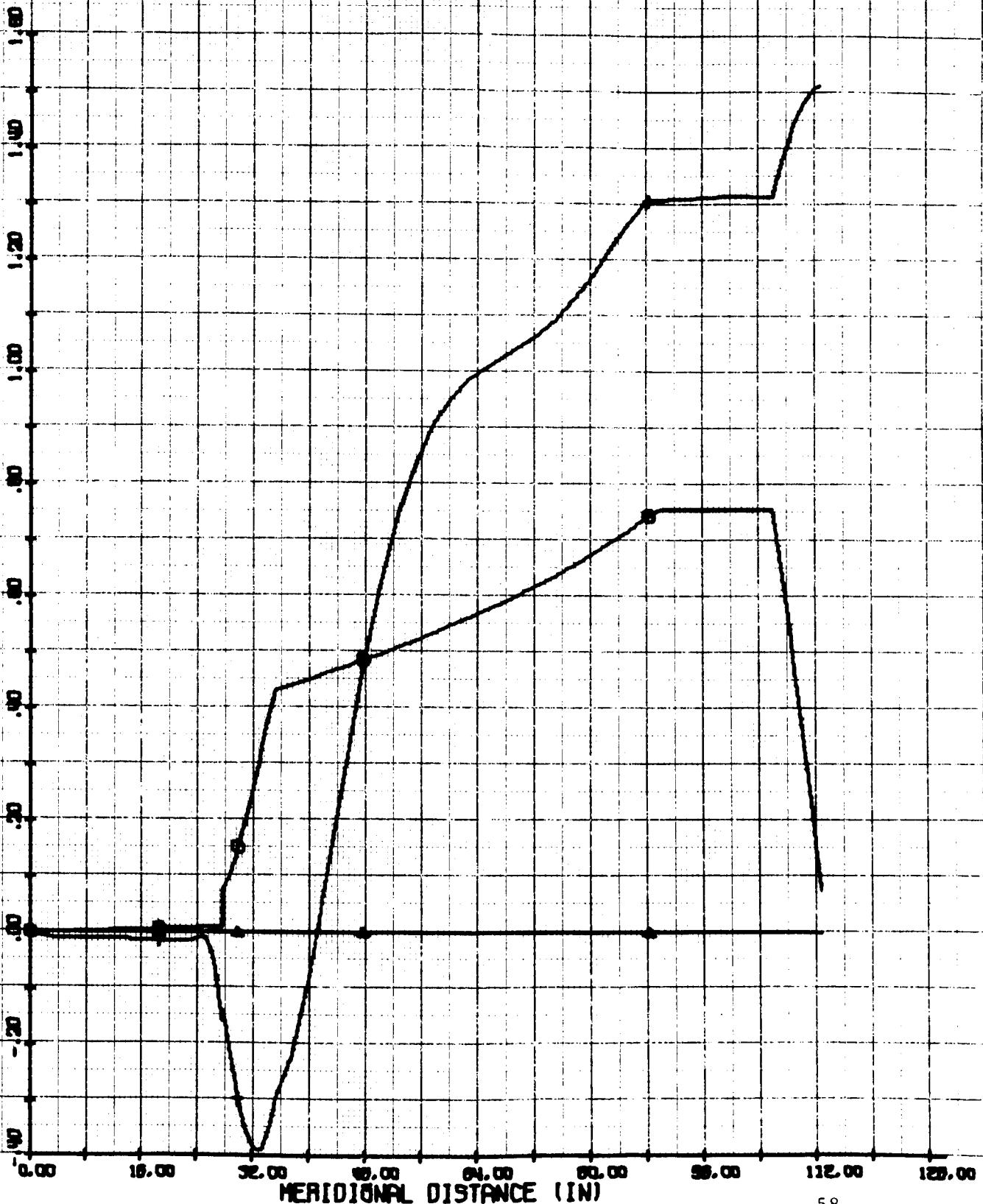


FIGURE 17b

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE 1 (120 IN BASE). OMEGA 2 = 65.58 CPS (N=0)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

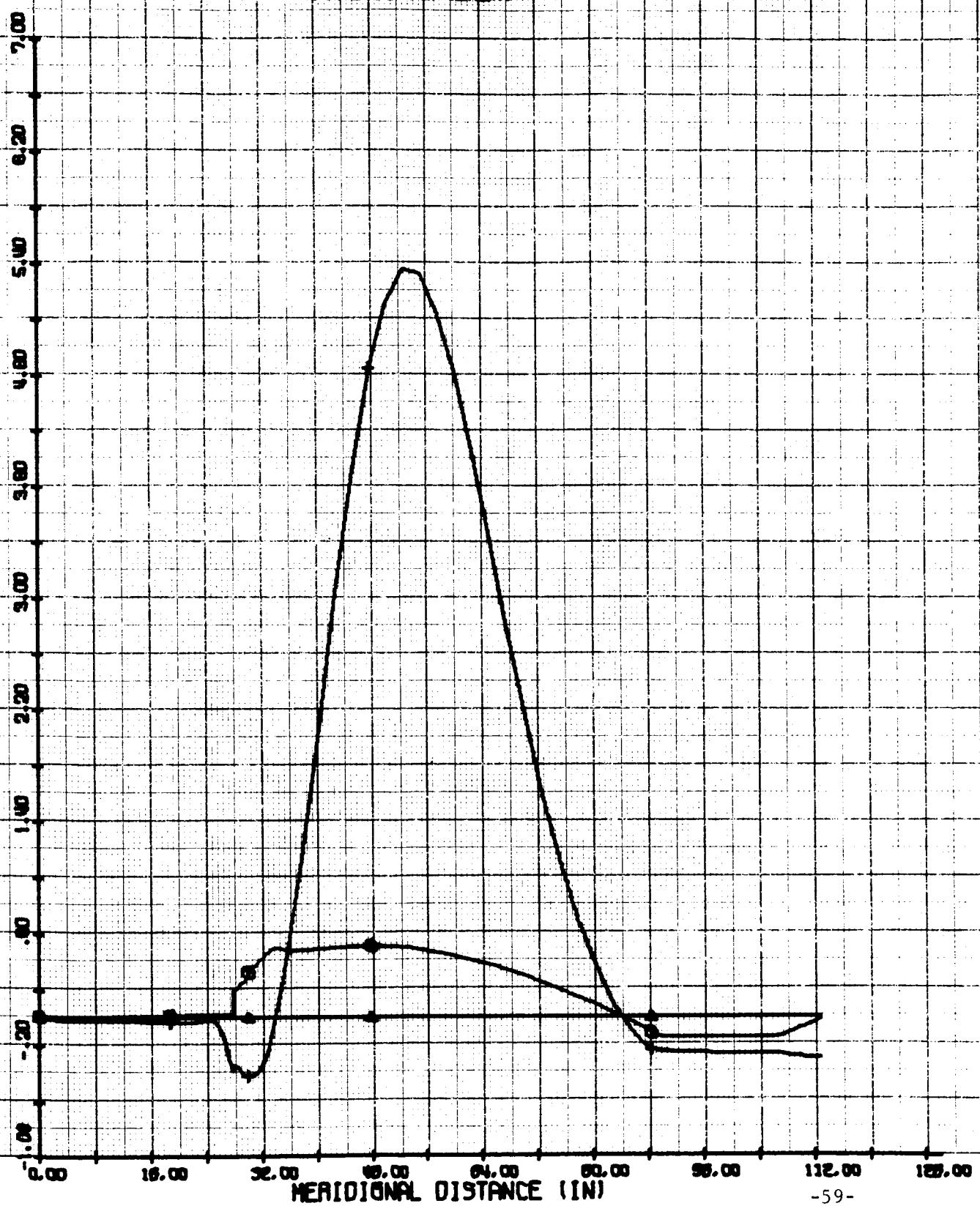


FIGURE 17C

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE 1 (120 IN BRSE). OMEGA 3 = 75.89 CPS (N=0)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

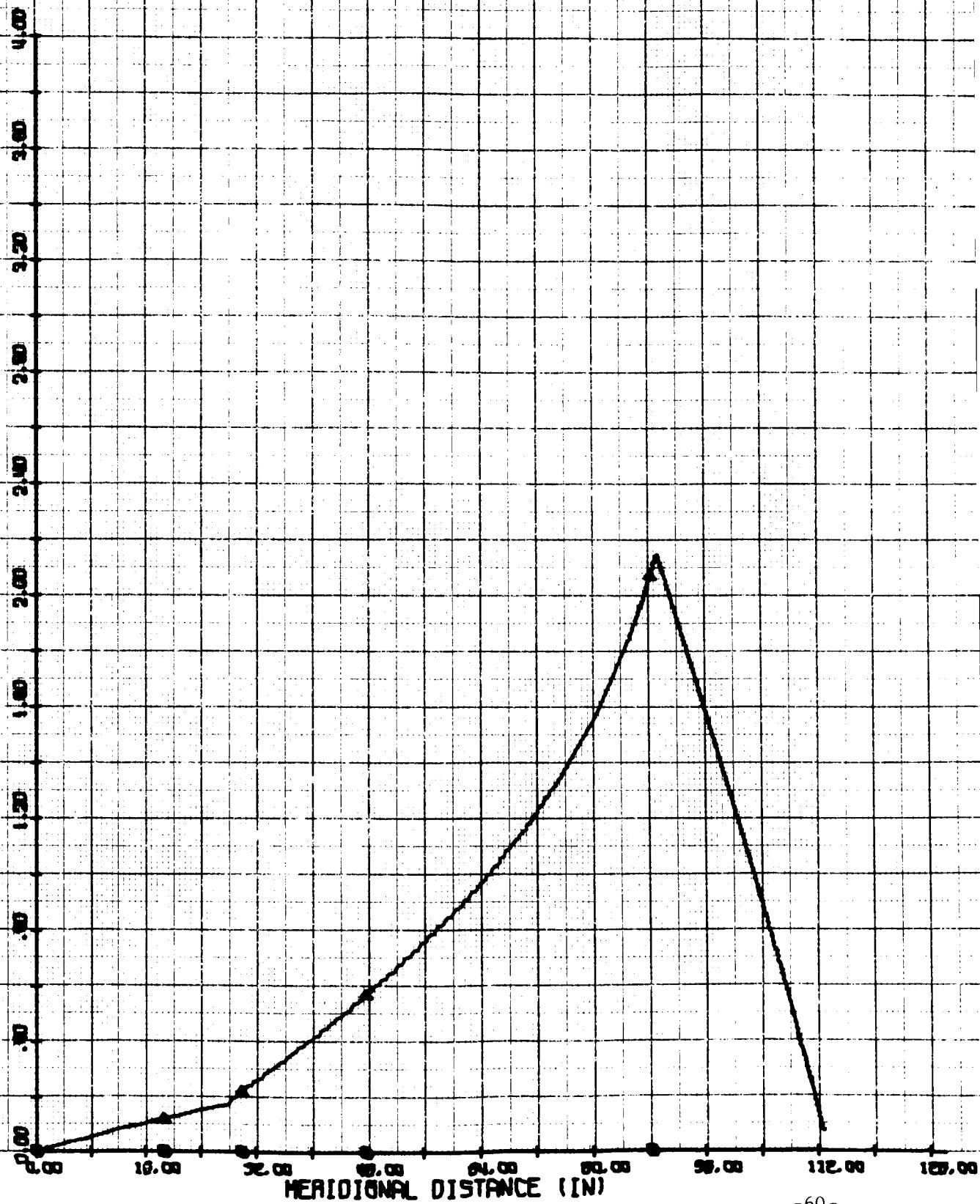


FIGURE 18a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE 1 (120 IN BASE), OMEGA 1 = 17.88 CPS (IN=1)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + RADIAL DISPLACEMENT

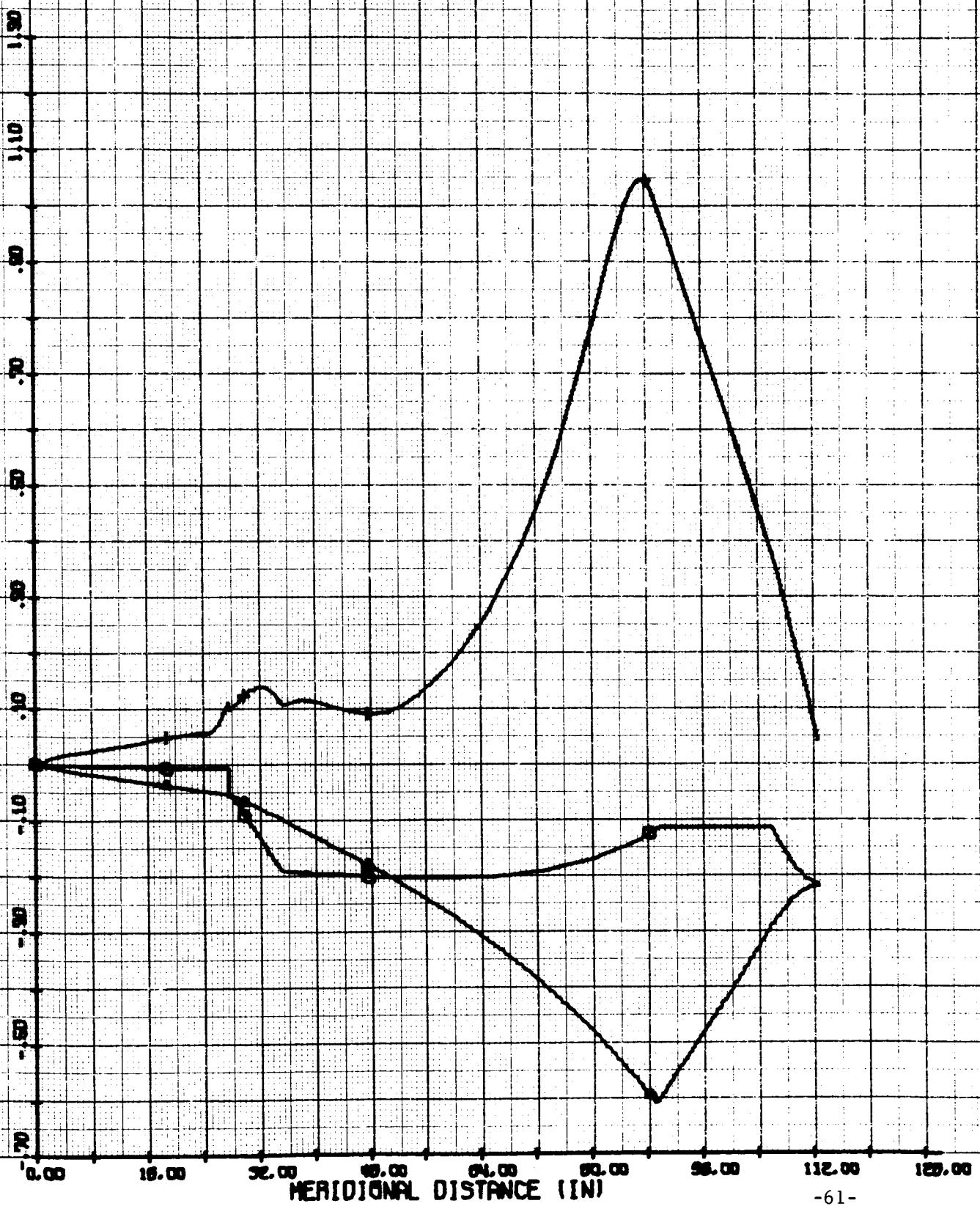


FIGURE 18b

VIBRATION MODE DISPLACEMENTS

NRSA TASK 3. CASE I (120 IN BASE). OMEGA 2 = 36.52 CPS (N=1)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

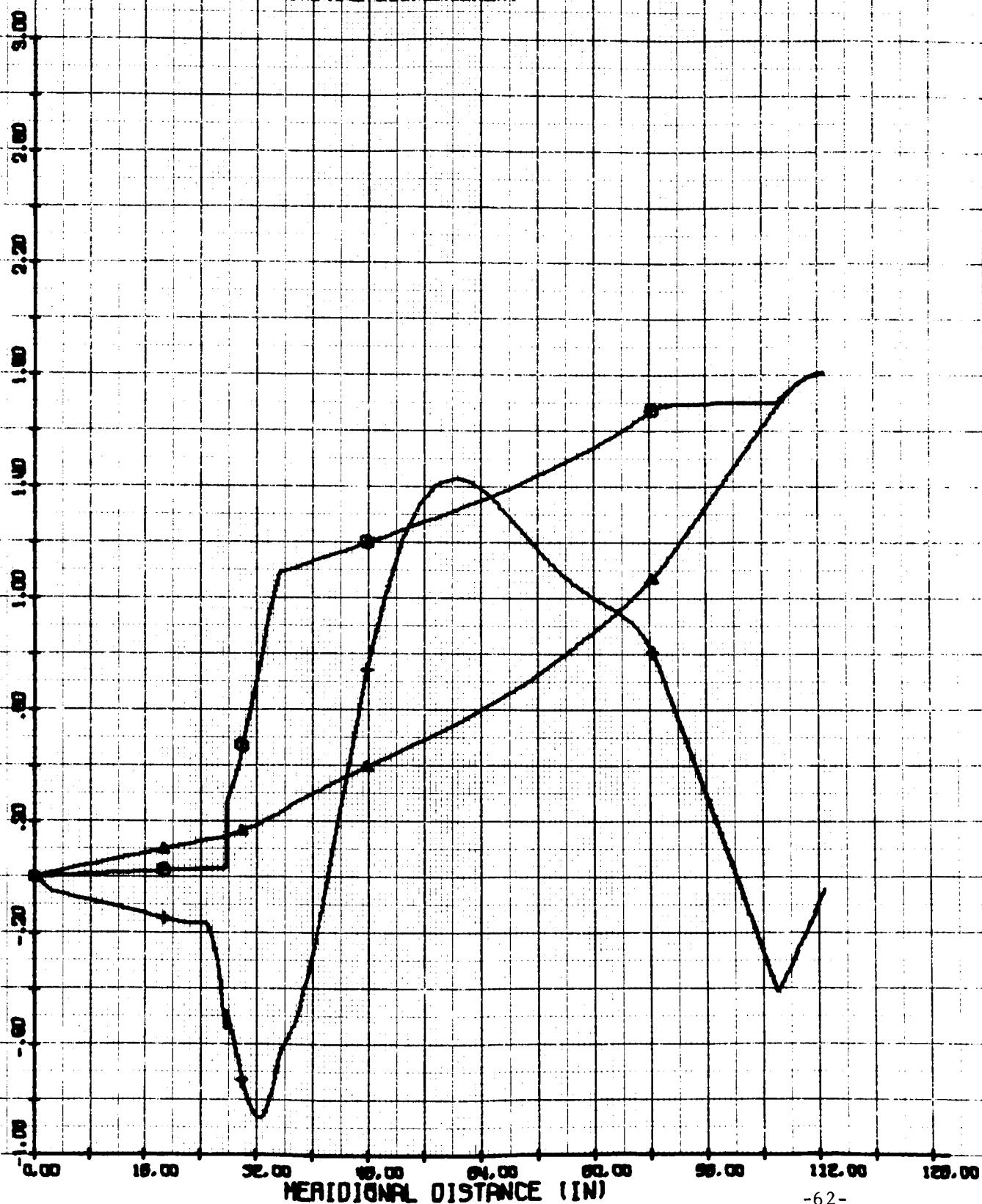


FIGURE 18c

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE 1 [120 IN BASE1. OMEGA 3 = 62.67 EPS (IN=1)]

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8

0.00

16.00

32.00

48.00

64.00

80.00

96.00

112.00

128.00

MERIDIONAL DISTANCE (IN)

FIGURE 19a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (120 IN BASE). OMEGA 1 = 48.62 CPS (N=2)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

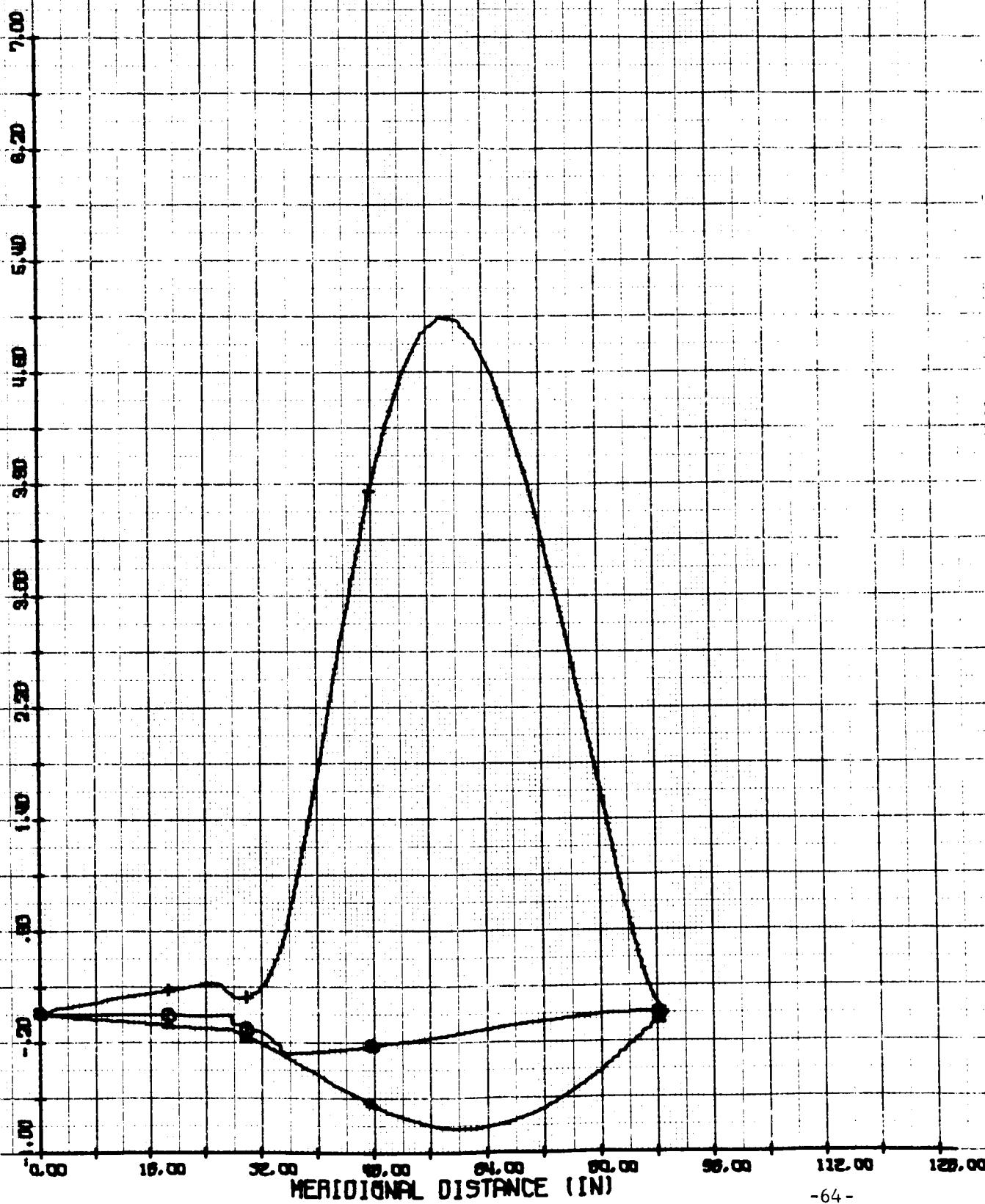


FIGURE 196

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE 1 (120 IN BASE). OMEGA 2 = 79.80 CPS (IN=2)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

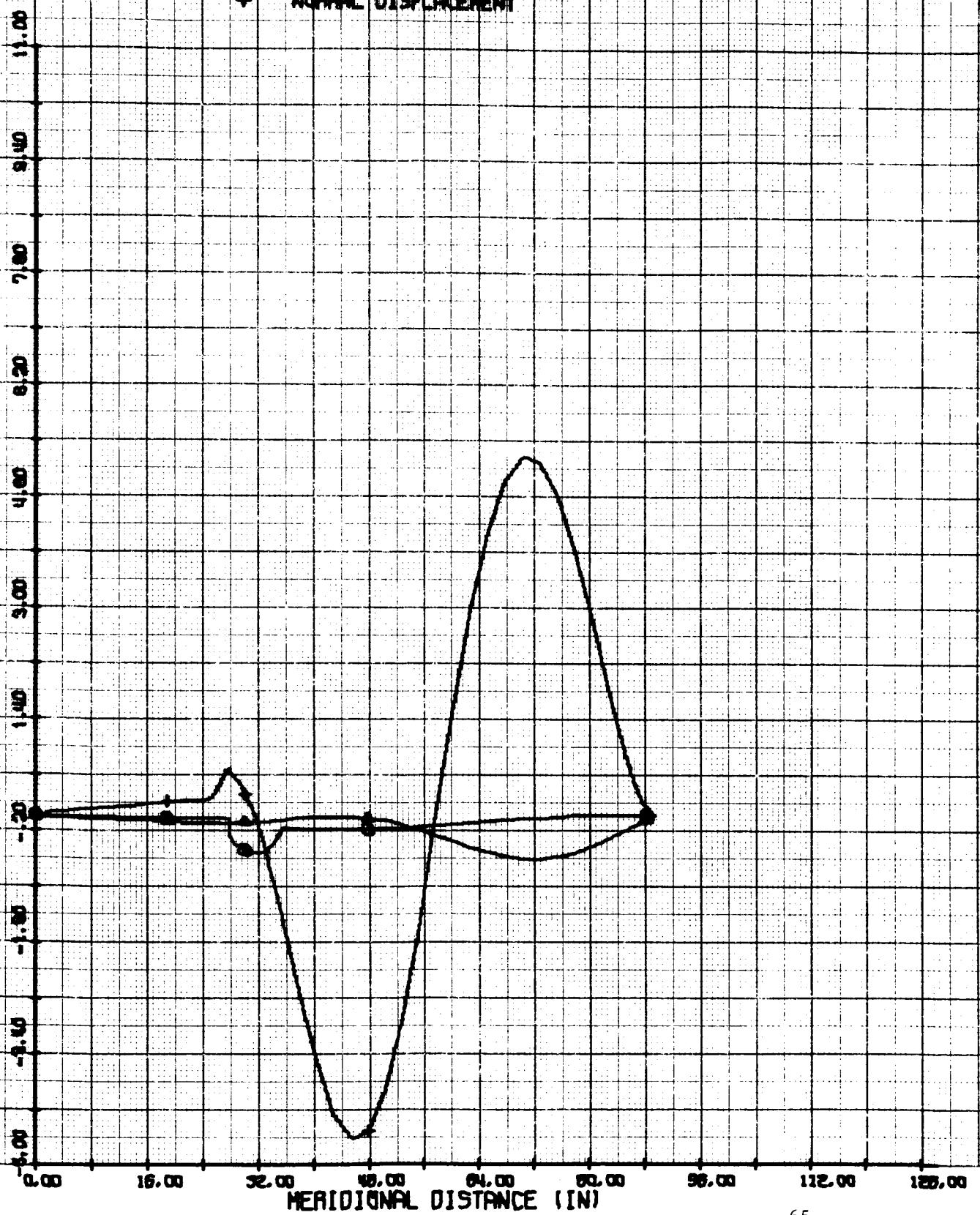


FIGURE 19c

VIBRATION MODE DISPLACEMENTS

NRSP TASK 3. CASE I (120 IN BASE). OMEGA 3 = 114.5 CPS (N=2)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

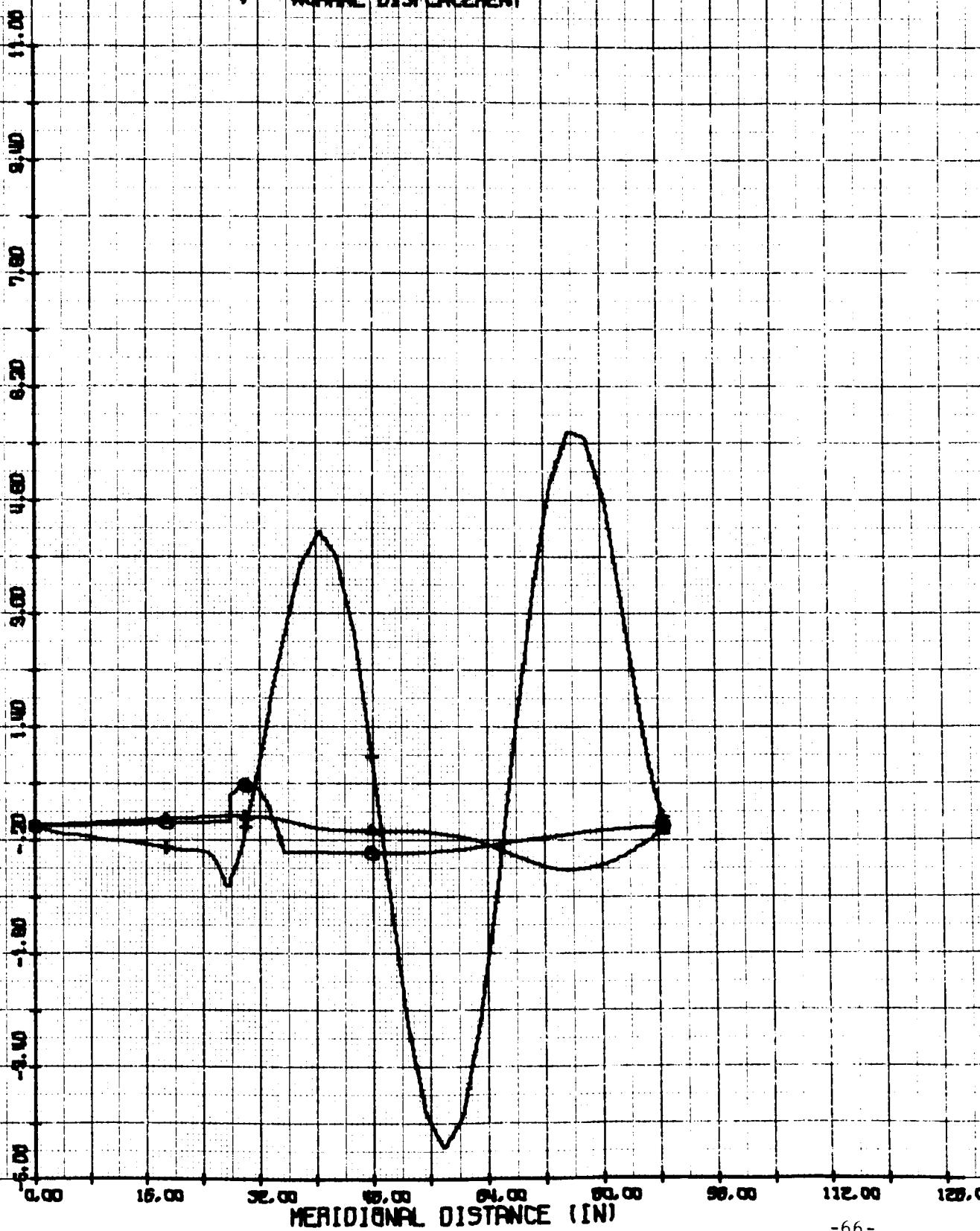


FIGURE 20a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE 1 (1120 IN BASE). OMEGA 1 = 39.02 CPS (N=3)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

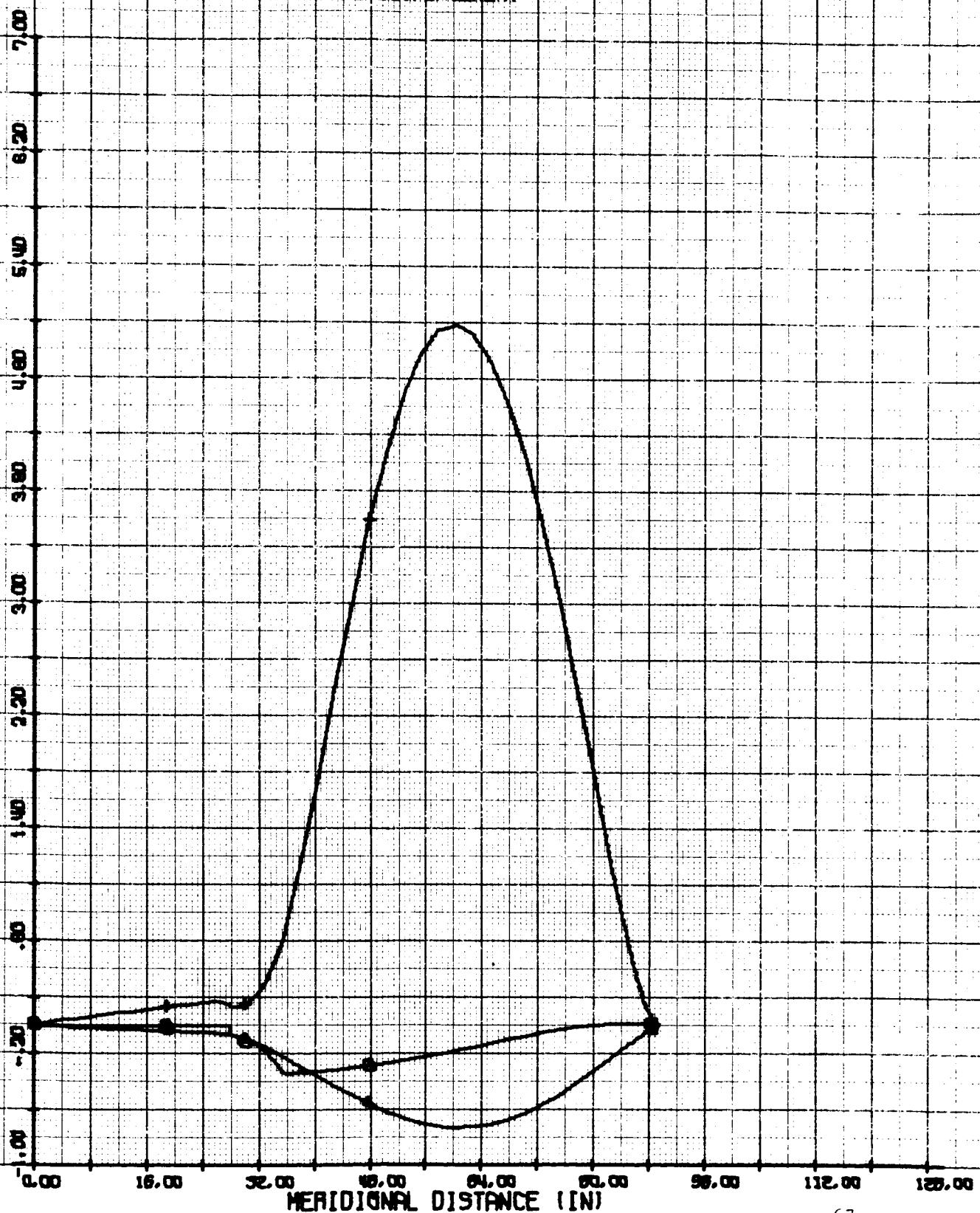


FIGURE 20b

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (120 IN BASE). OMEGA 2 = 76.80 CPS [N=3]

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

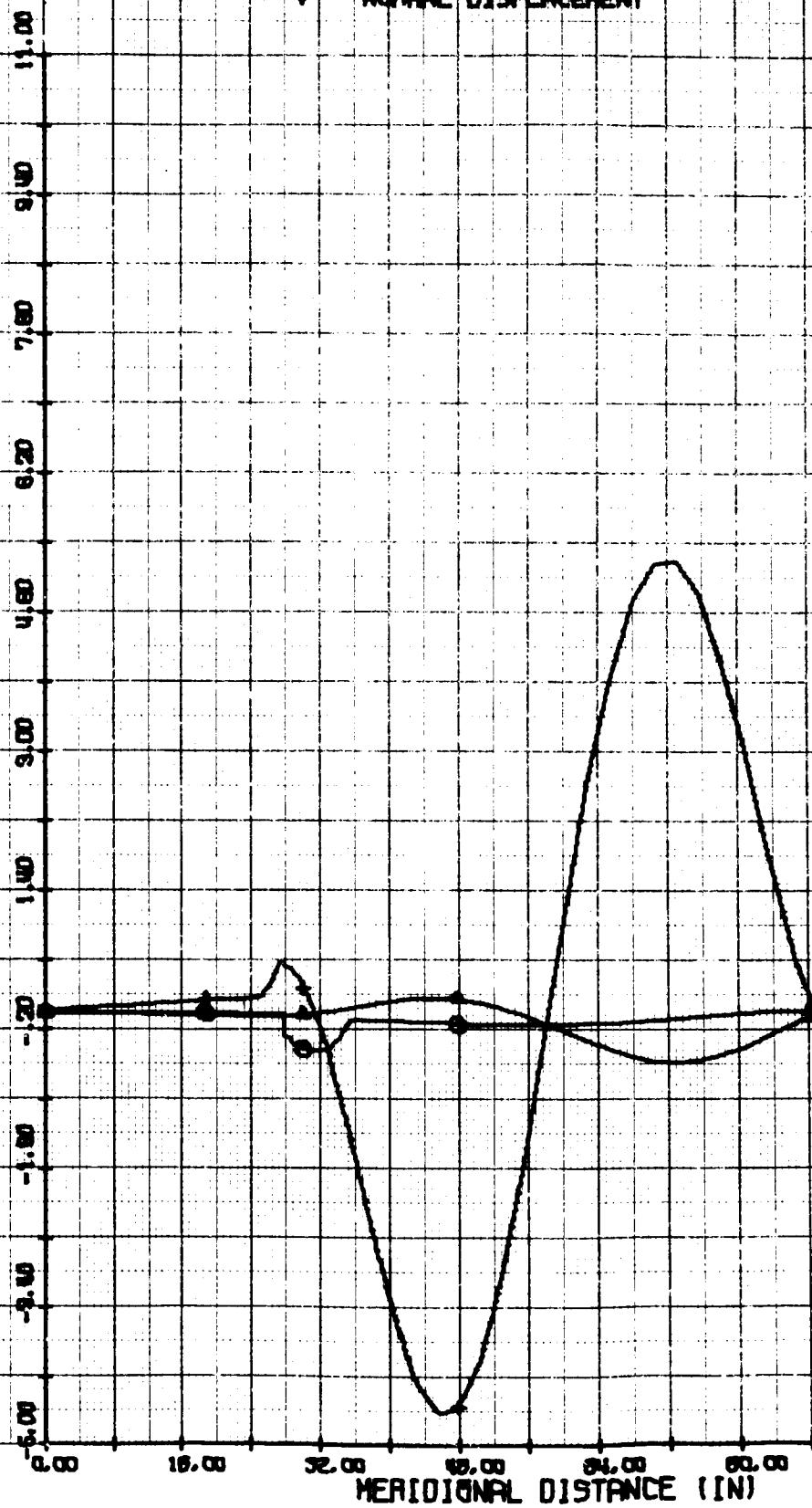


FIGURE 20c

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE 1 (120 IN BASE). OMEGA 3 = 115.6 CPS (N=3)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

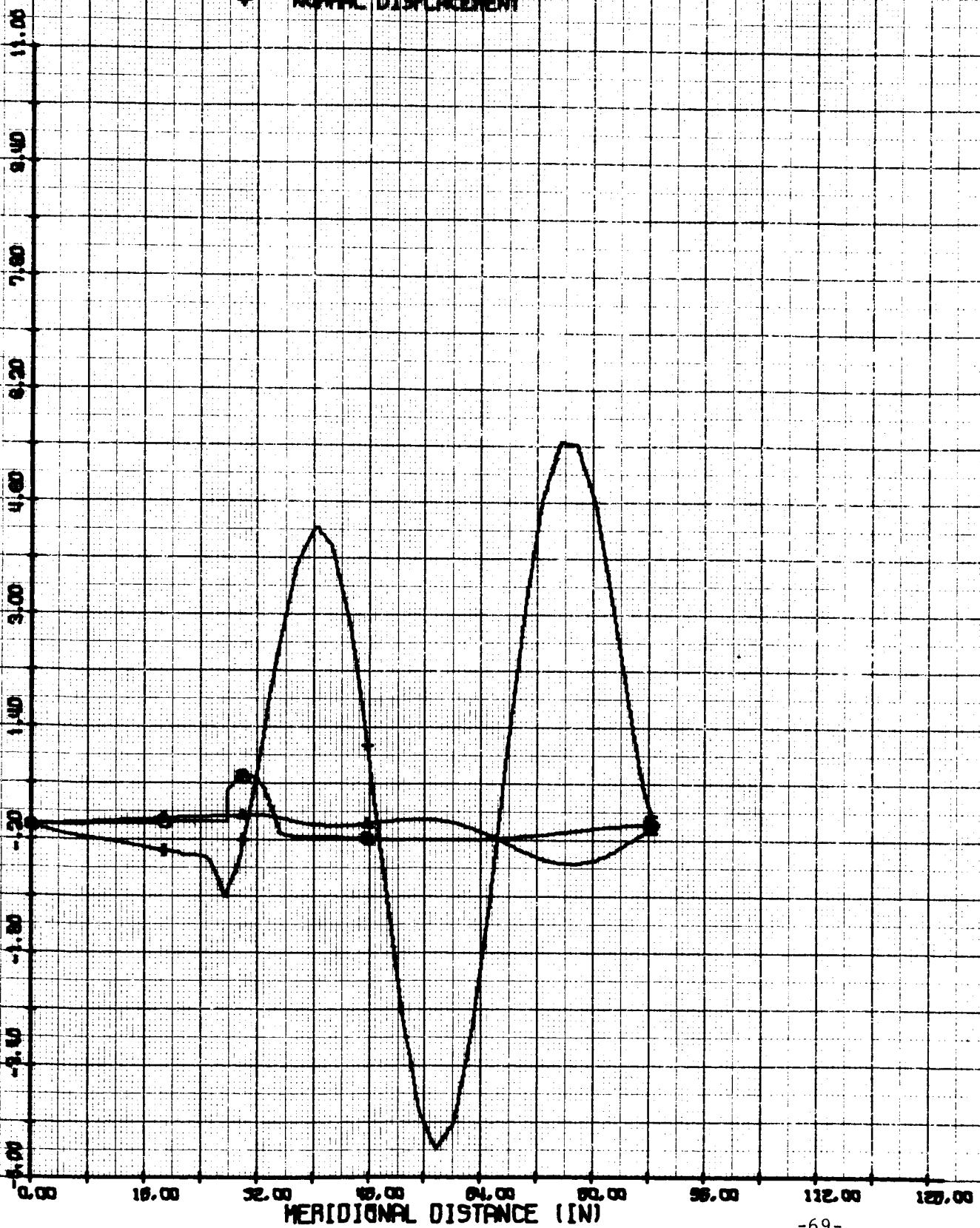


FIGURE 21a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE 1 (1120 IN BASE). OMEGA 1 = 38.30 CPS (N=4)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

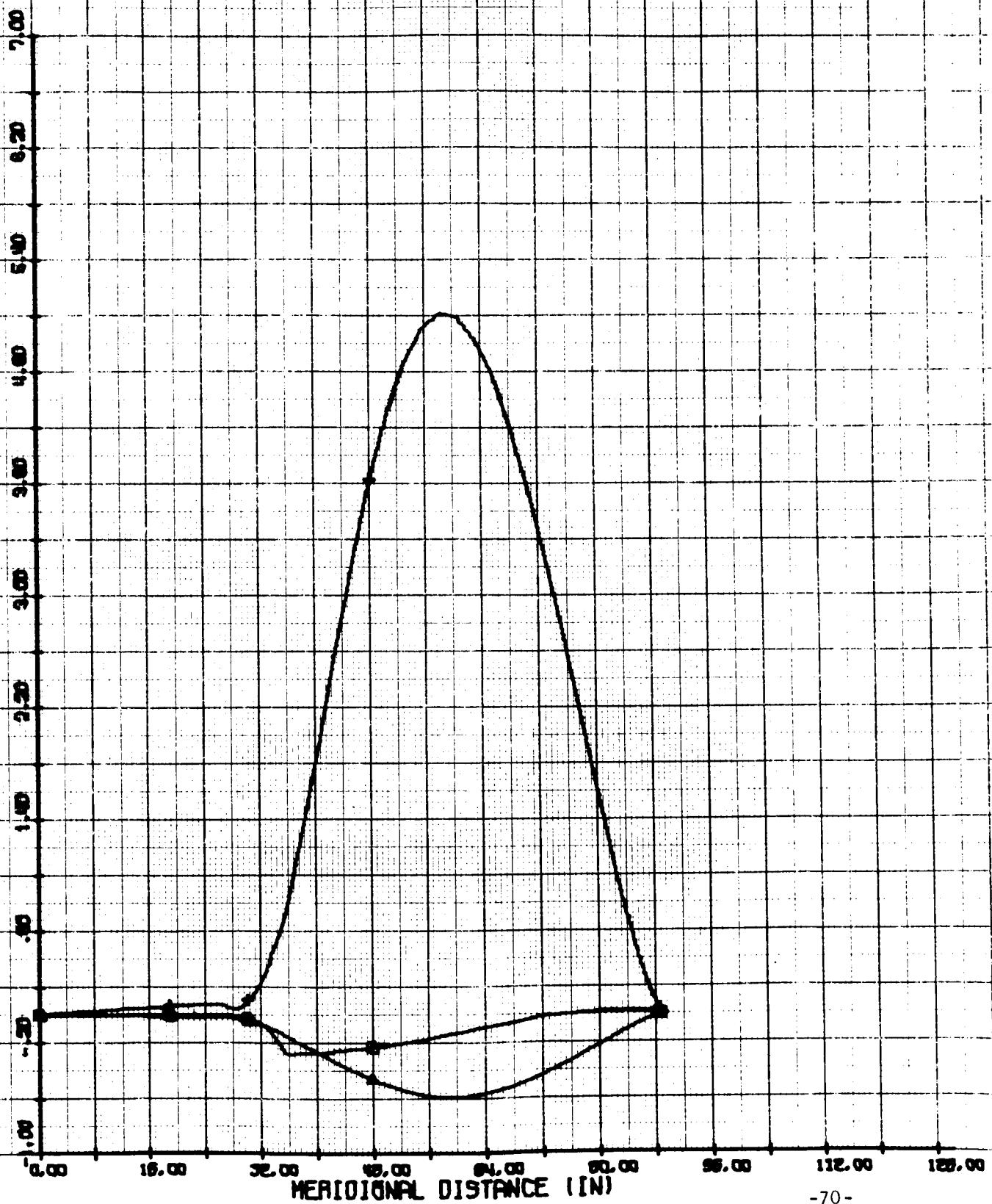


FIGURE 21b

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (120 IN BASE). OMEGA 2 = 78.20 CPS (N=4)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

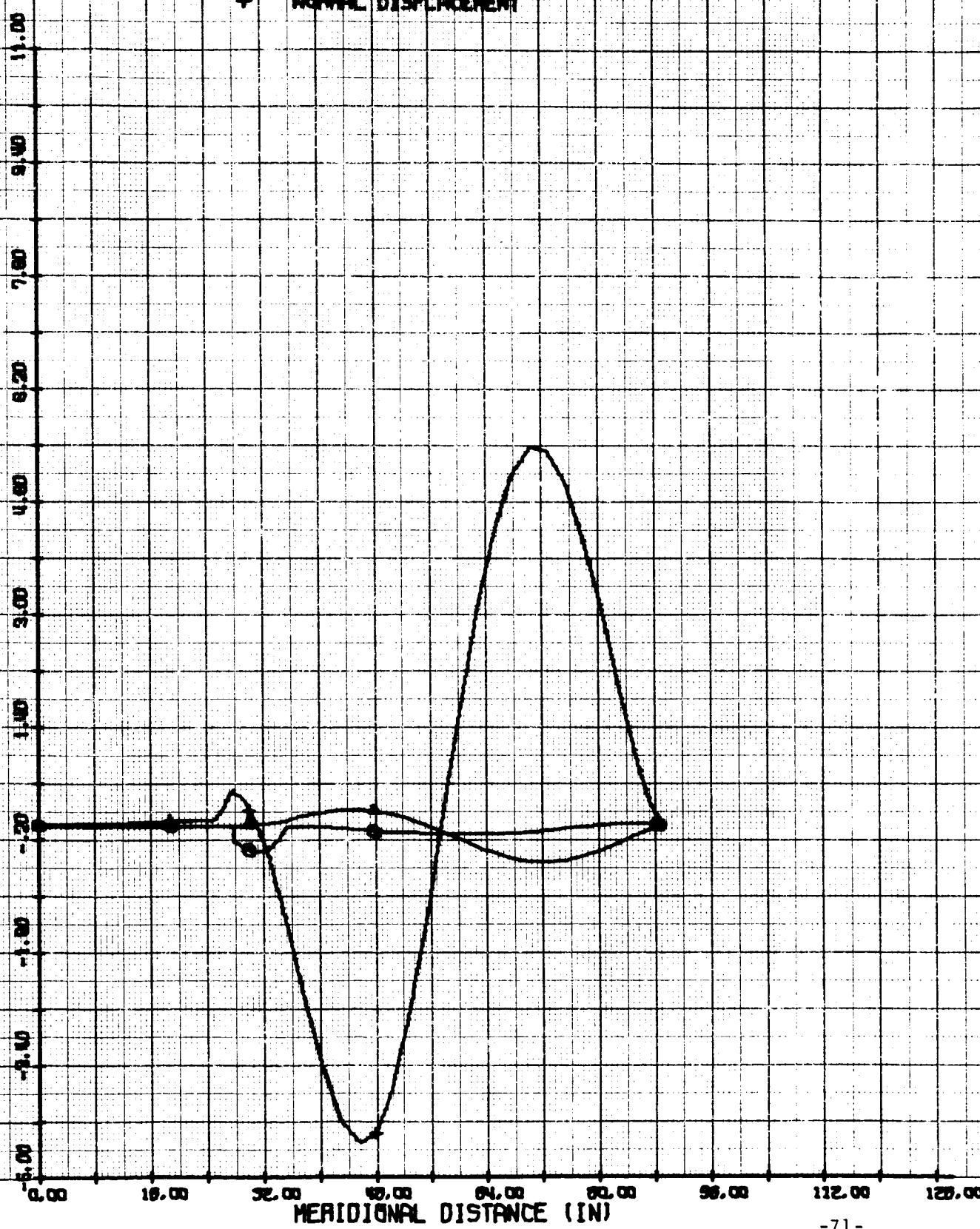


FIGURE 21c

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE I (120 IN BASE). OMEGA 3 = 120.8 CPS (IN=4)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

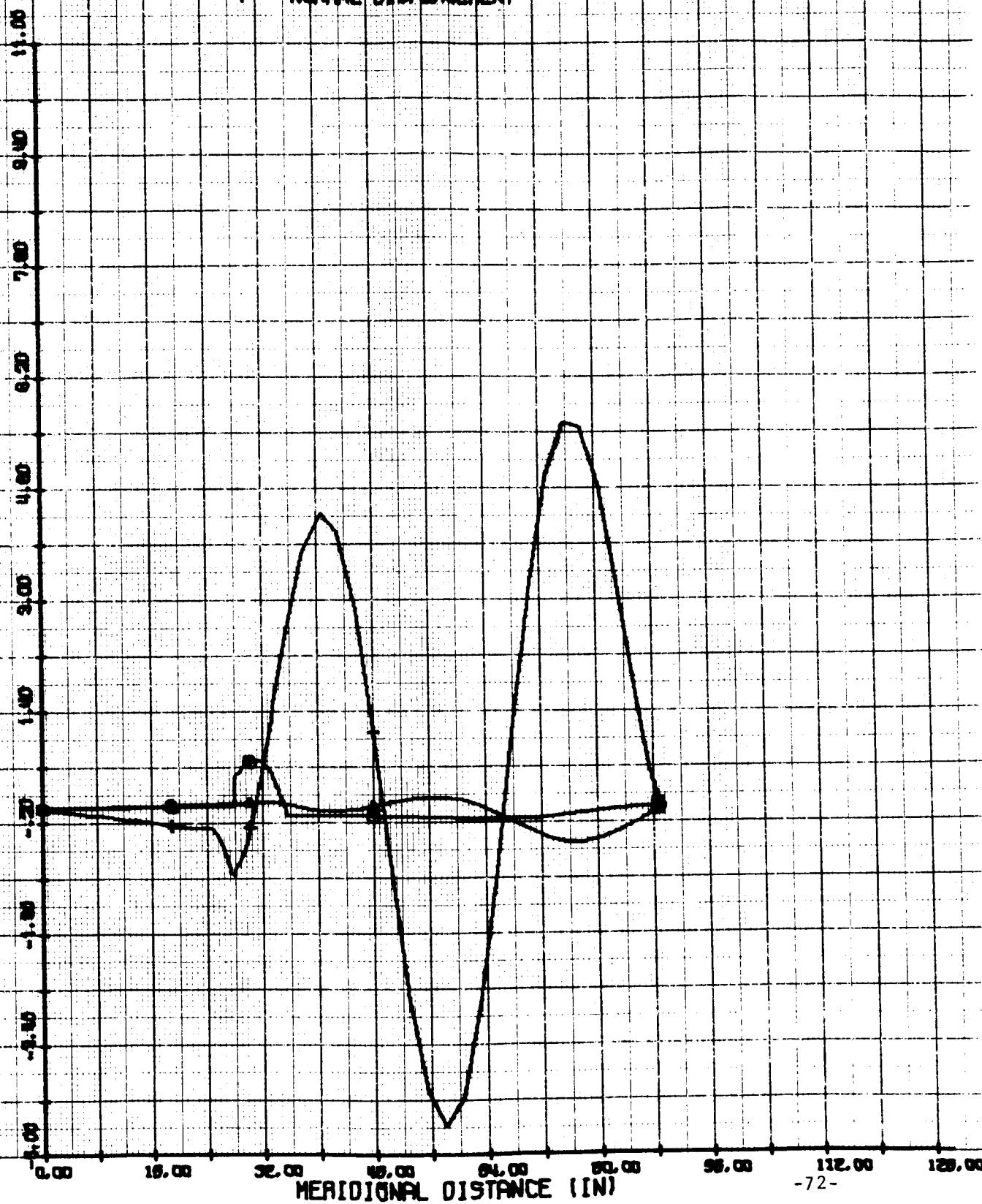


FIGURE 22a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE 1 (120 IN BASE). OMEGA 1 = 43.88 CPS (N=5)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

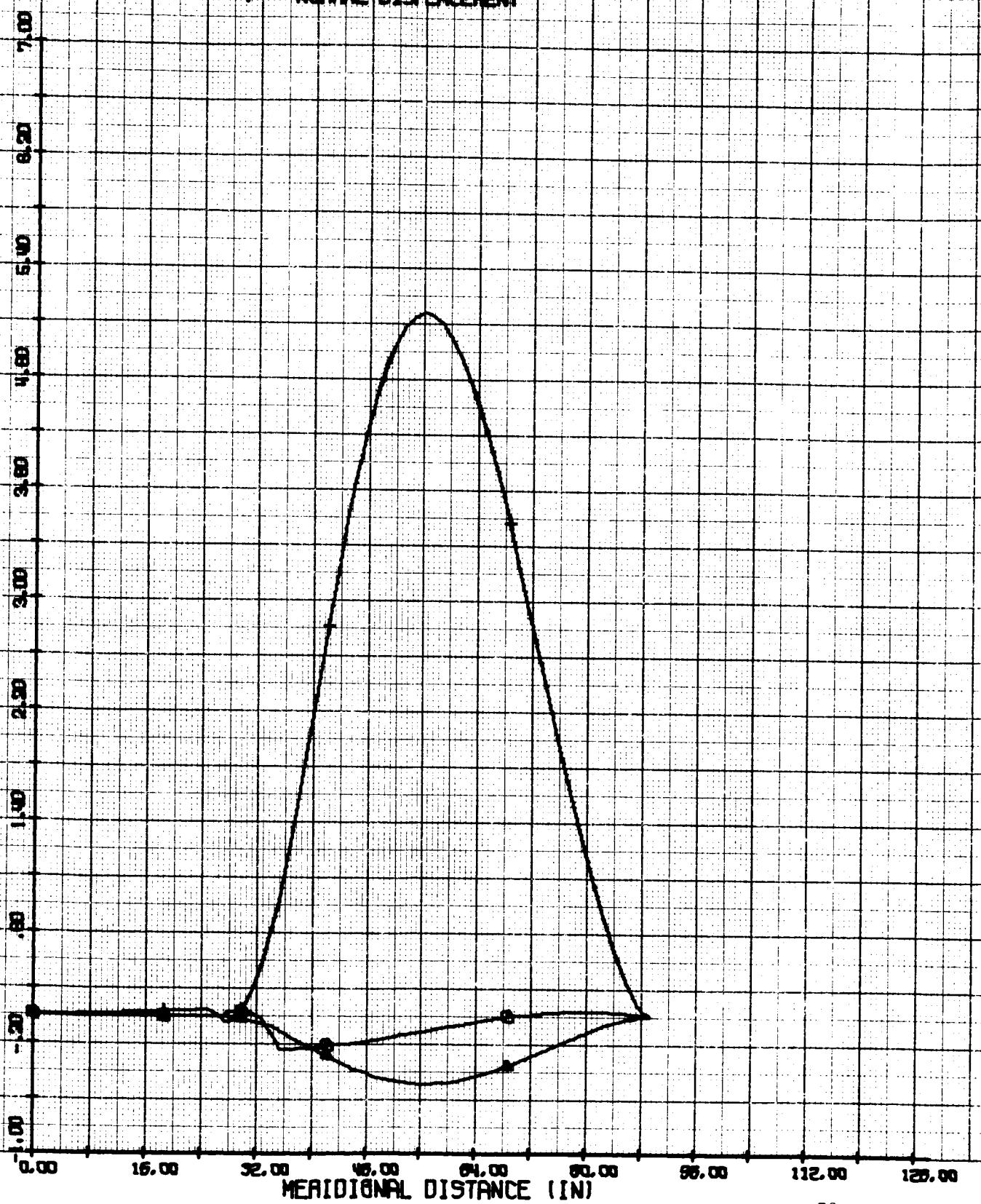


FIGURE 22b

VIBRATION MODE DISPLACEMENTS

NPSR TASK 3. CASE I (120 IN BASE). OMEGA 2 = 84.76 CPS (IN/S)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

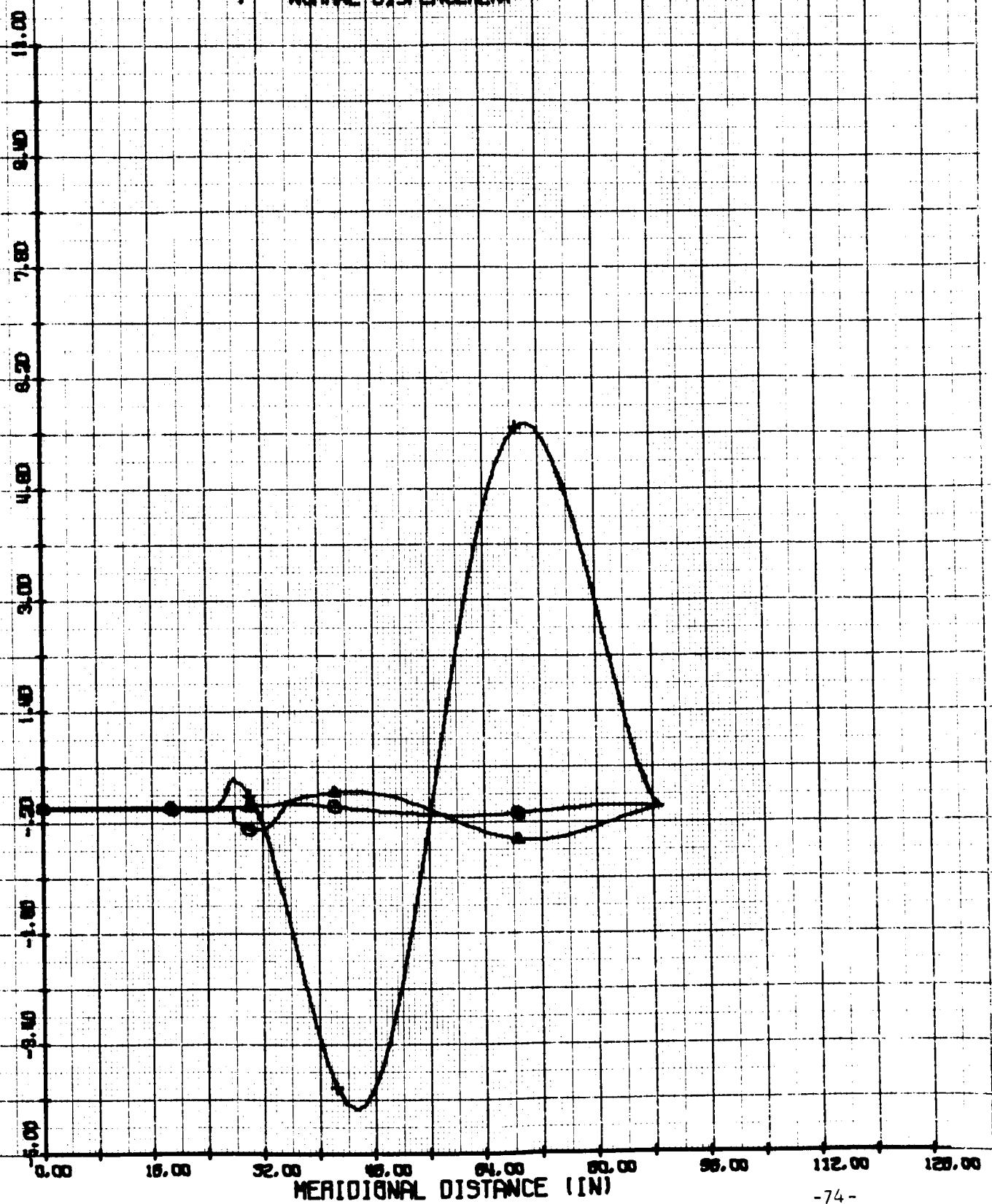


FIGURE 22c

VIBRATION MODE DISPLACEMENTS

NRSP TASK 3, CASE 1 (120 IN BASE), OMEGA 3 = 130.4 CPS (IN/S)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

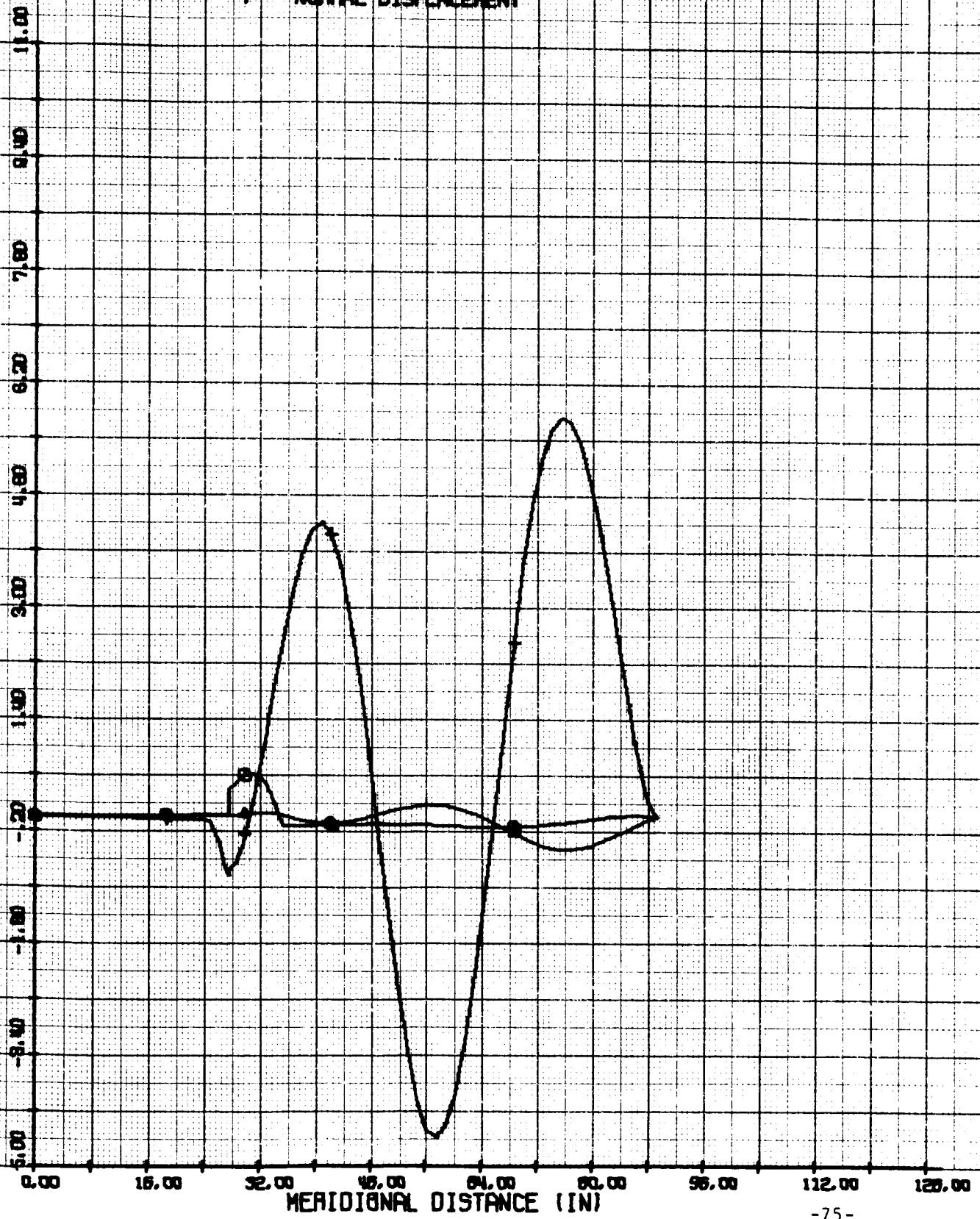


FIGURE 28a

VIBRATION MODE DISPLACEMENTS

NRP TASK 3, CASE 1 (1120 IN BRSE). OMEGA 1 = 53.12 CPS (N=6)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

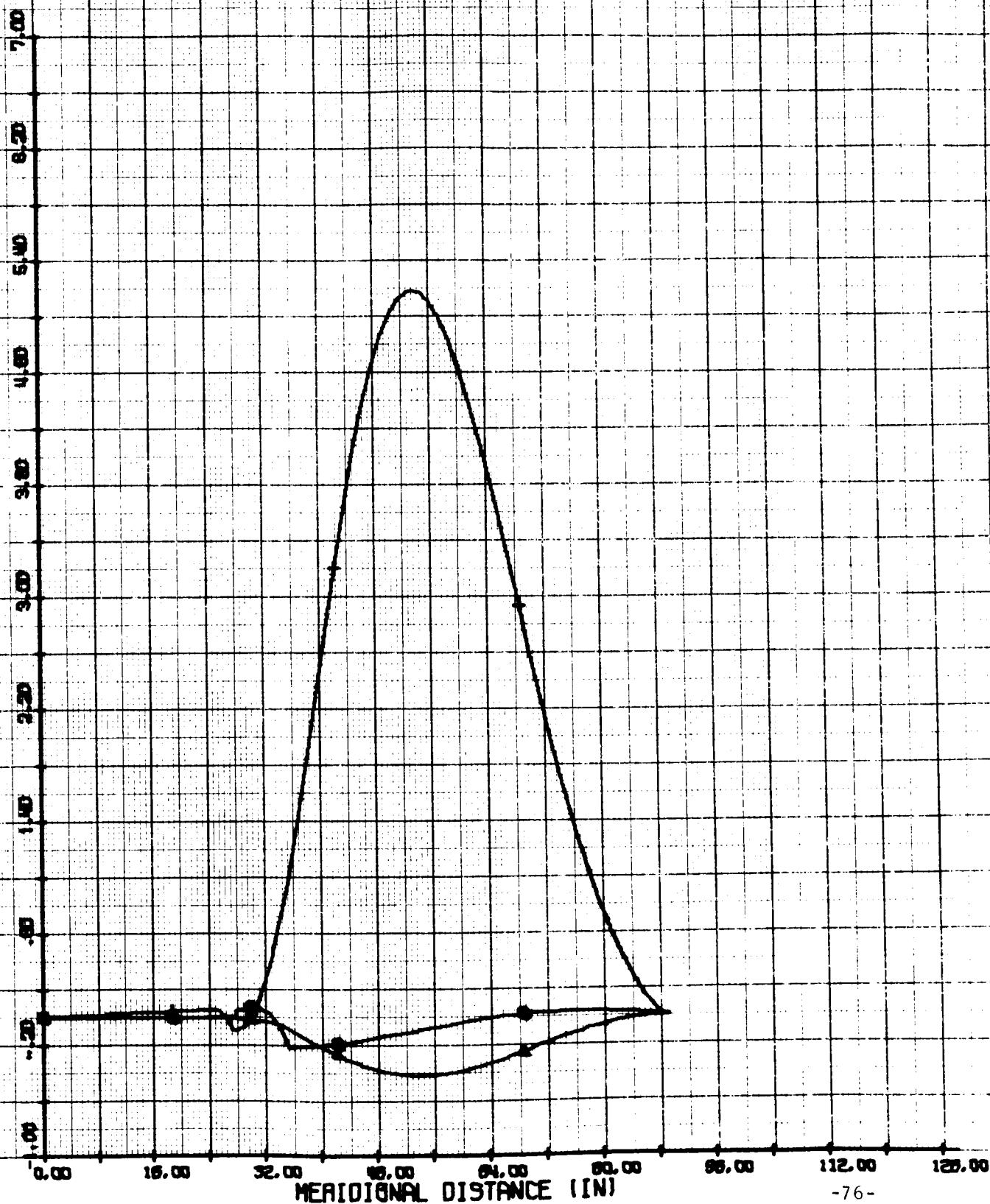


FIGURE 23b

VIBRATION MODE DISPLACEMENTS

NPSR TASK 3. CASE I (120 IN BASE). OMEGA 2 = 86.13 CPS (N=6)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

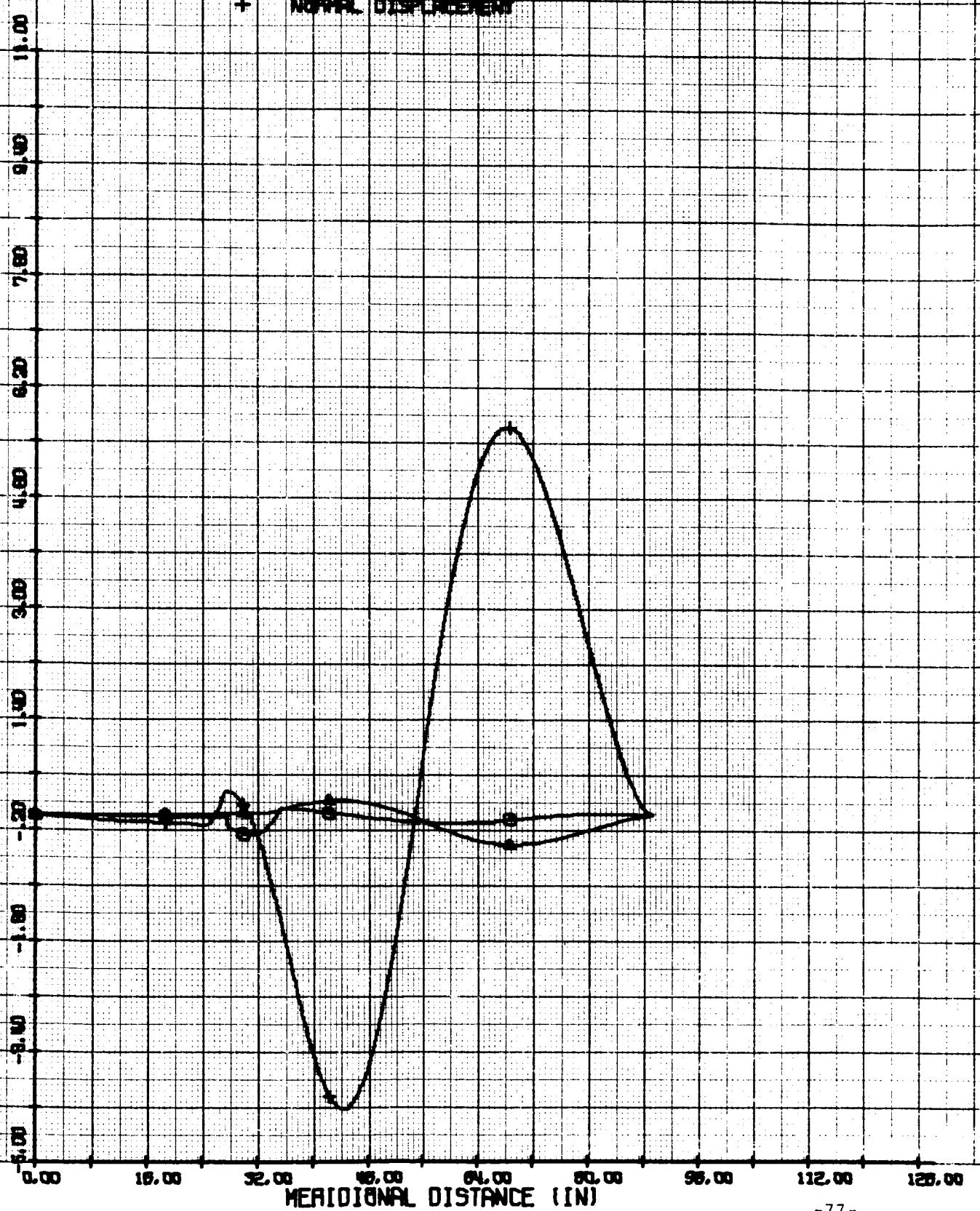


FIGURE 23c

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE 1 (120 IN BASE). OMEGA 3 = 144.3 CPS (IN=6)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

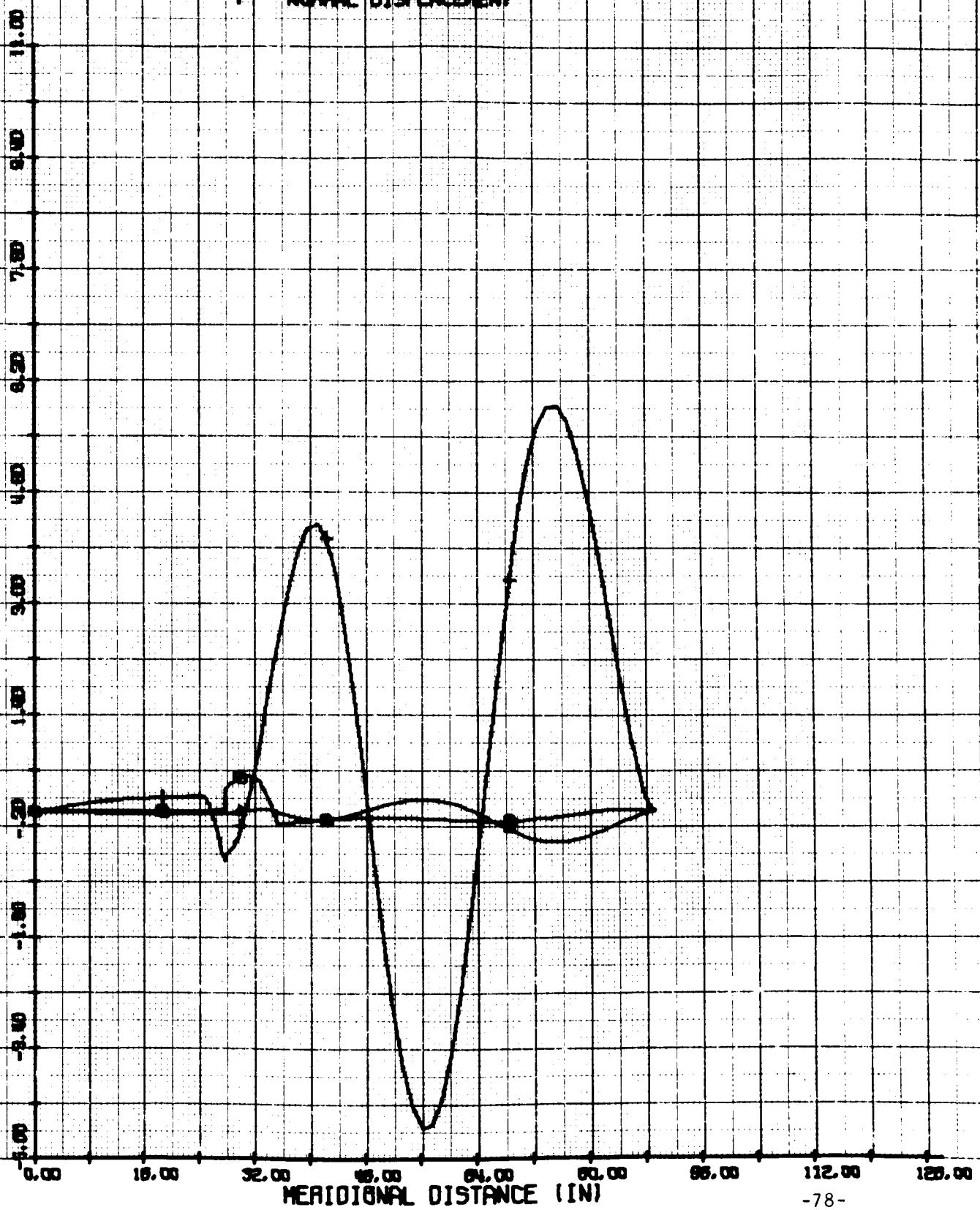


FIGURE 24-a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE 1 (1120 IN BASE). OMEGA 1 = 64.63 CPS (N=7)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

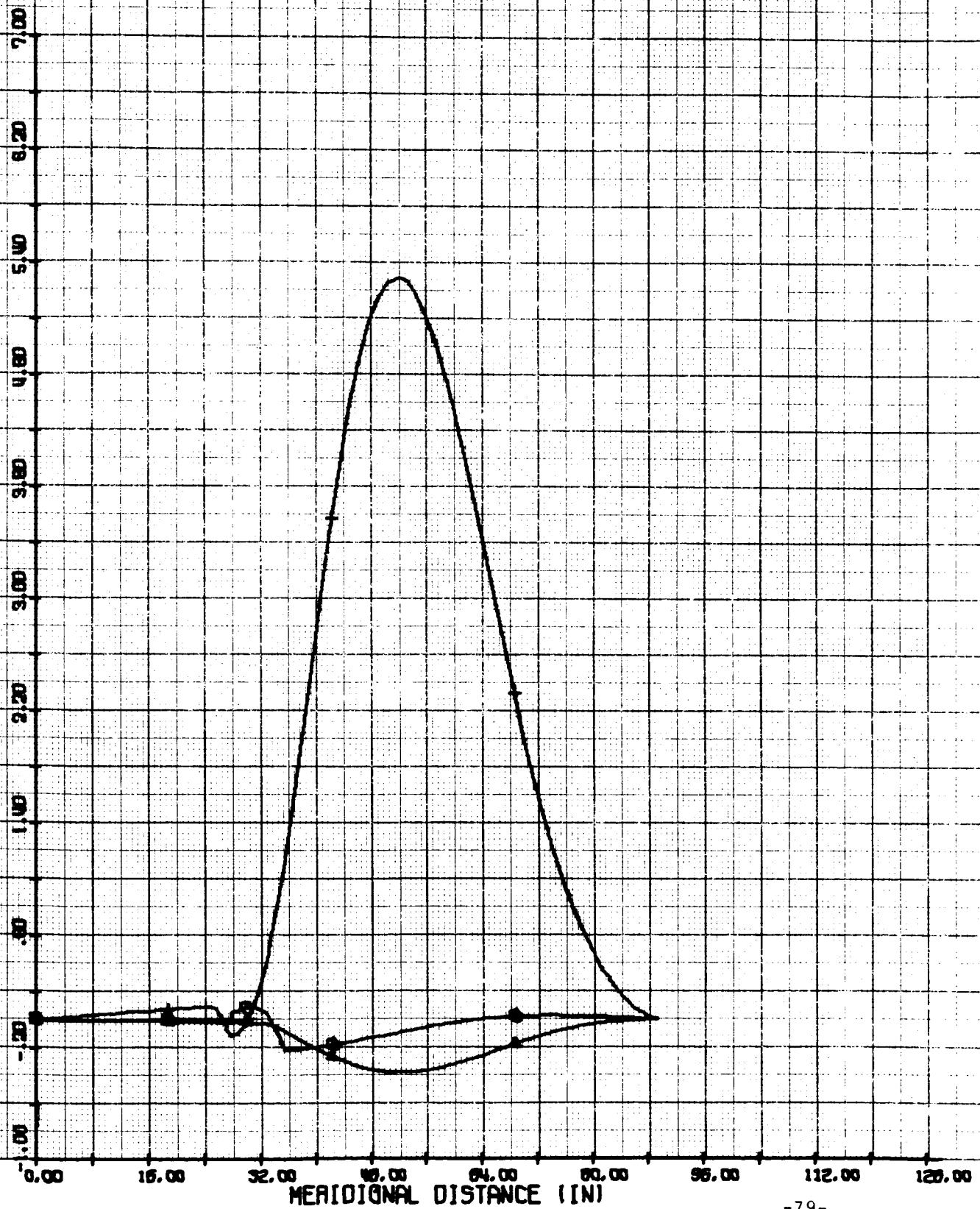
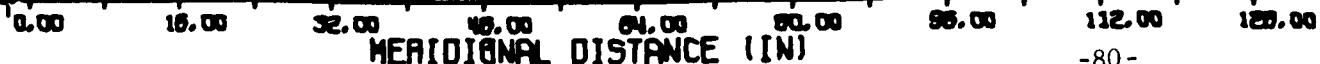


FIGURE 24b

VIBRATION MODE DISPLACEMENTS

NASA TRSK 3. CASE 1 1120 IN BASE1. OMEGA 2 = 111.0 CPS (IN=7)

- MERIDIONAL DISPLACEMENT
- △ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT



MERIDIONAL DISTANCE (IN)

FIGURE 24c

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE 1 (120 IN BASE). OMEGA 3 = 162.1 CPS [N=7]

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

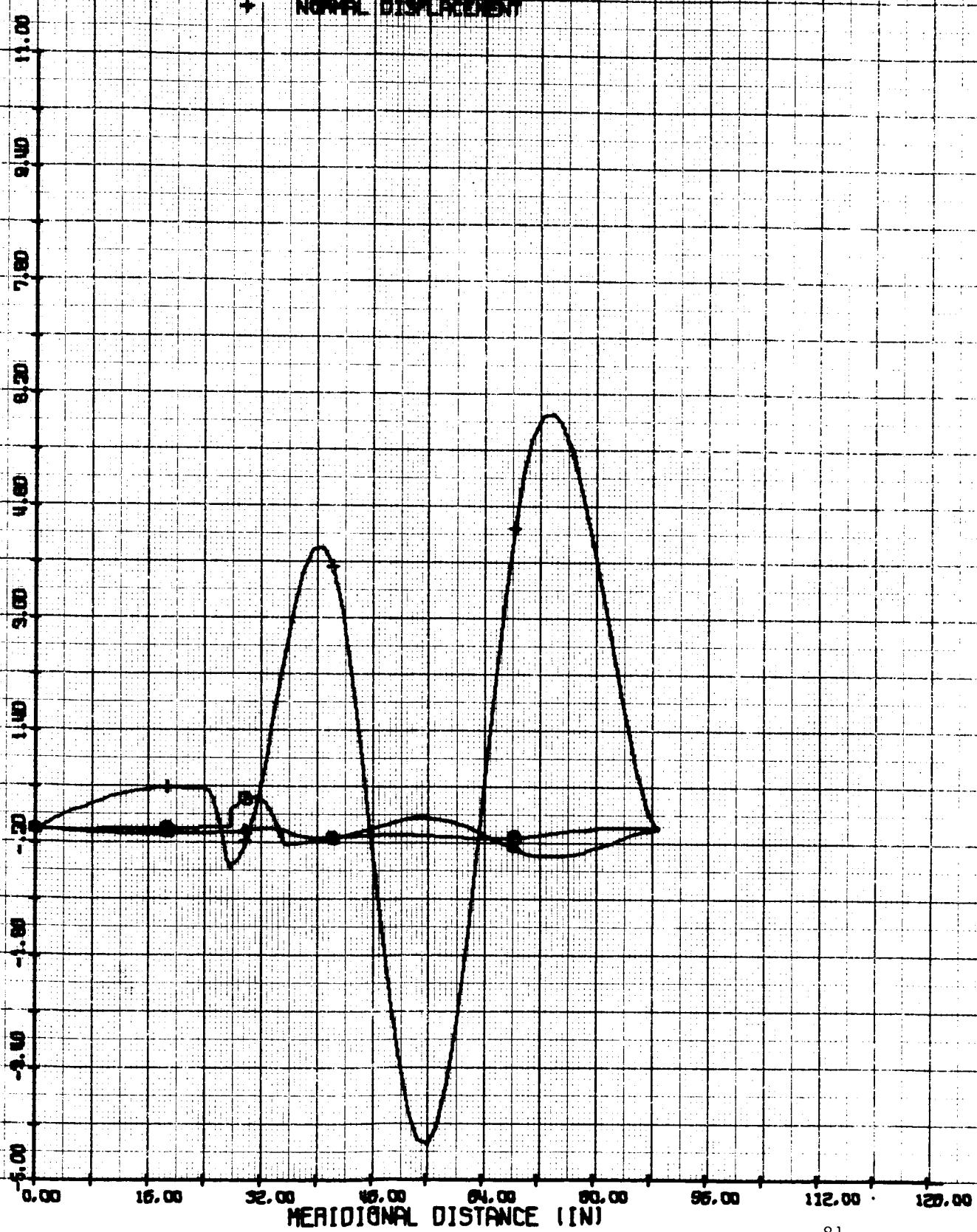


FIGURE 25a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE 1 (120 IN BASE). OMEGA 1 = 77.83 CPS (N=8)

○ MERIDIONAL DISPLACEMENT
▲ CIRCUMFERENTIAL DISPLACEMENT
+ NORMAL DISPLACEMENT

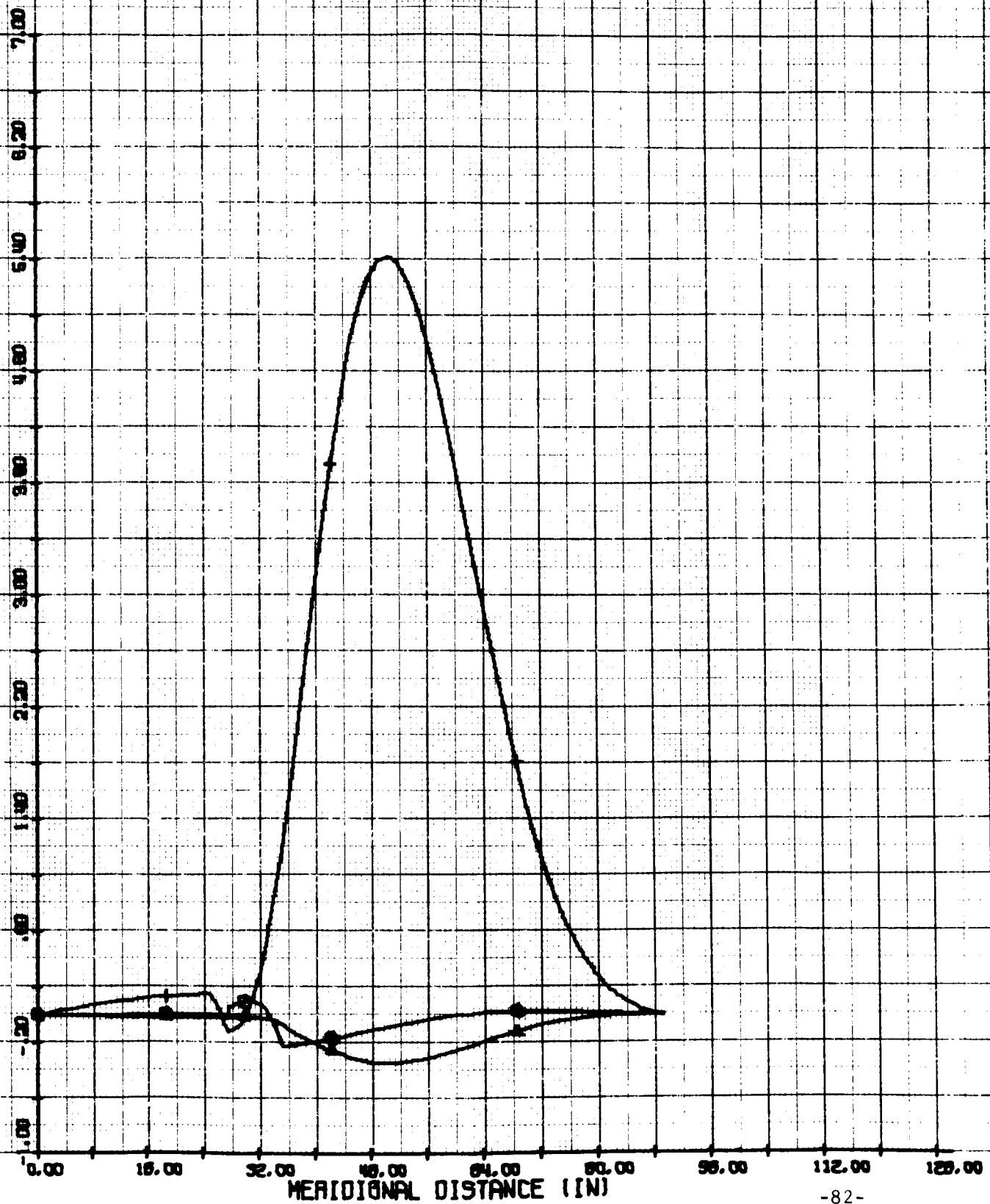


FIGURE 25b

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE 1 (1120 IN BASE1. OMEGA Z = 128.5 CPS (IN/S))

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

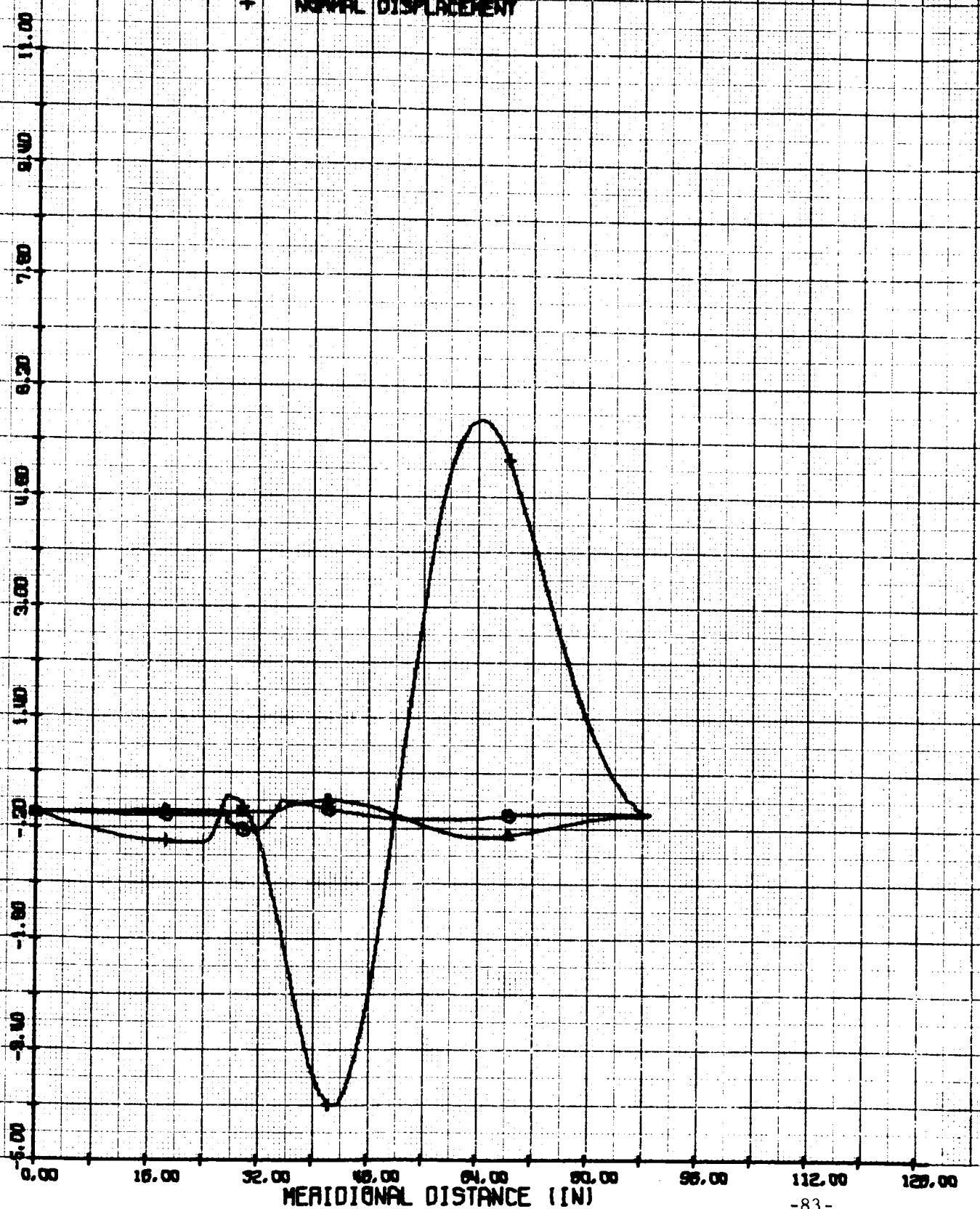


FIGURE 23c

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE 1 (1120 IN BASE). OMEGA 3 = 182.6 CPS (IN⁻¹)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

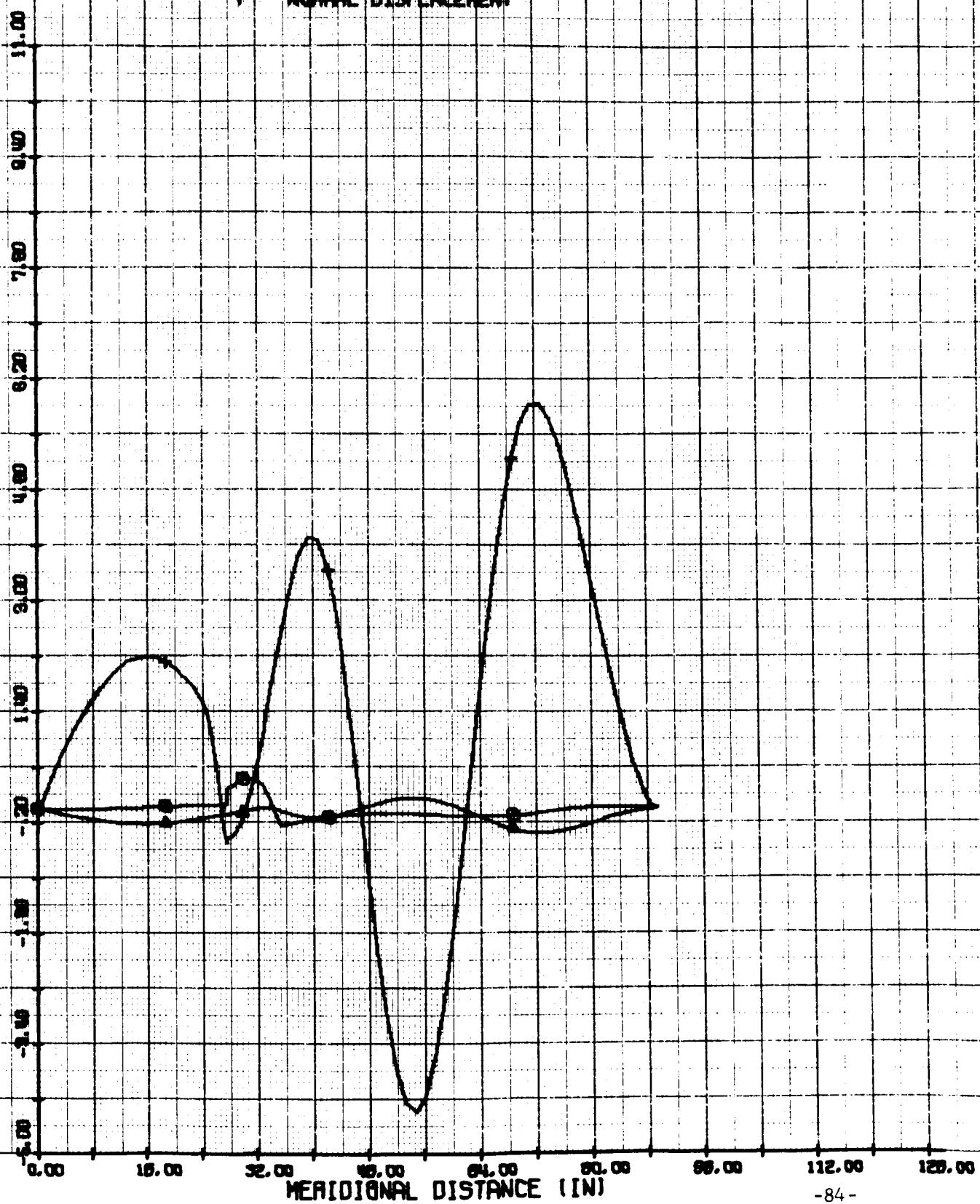


FIGURE 26a

VIBRATION MODE DISPLACEMENTS

NBSA TASK 3. CASE 1 (1120 IN BASE). OMEGA 1 = 92.45 CPS (IN-9)

- O MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

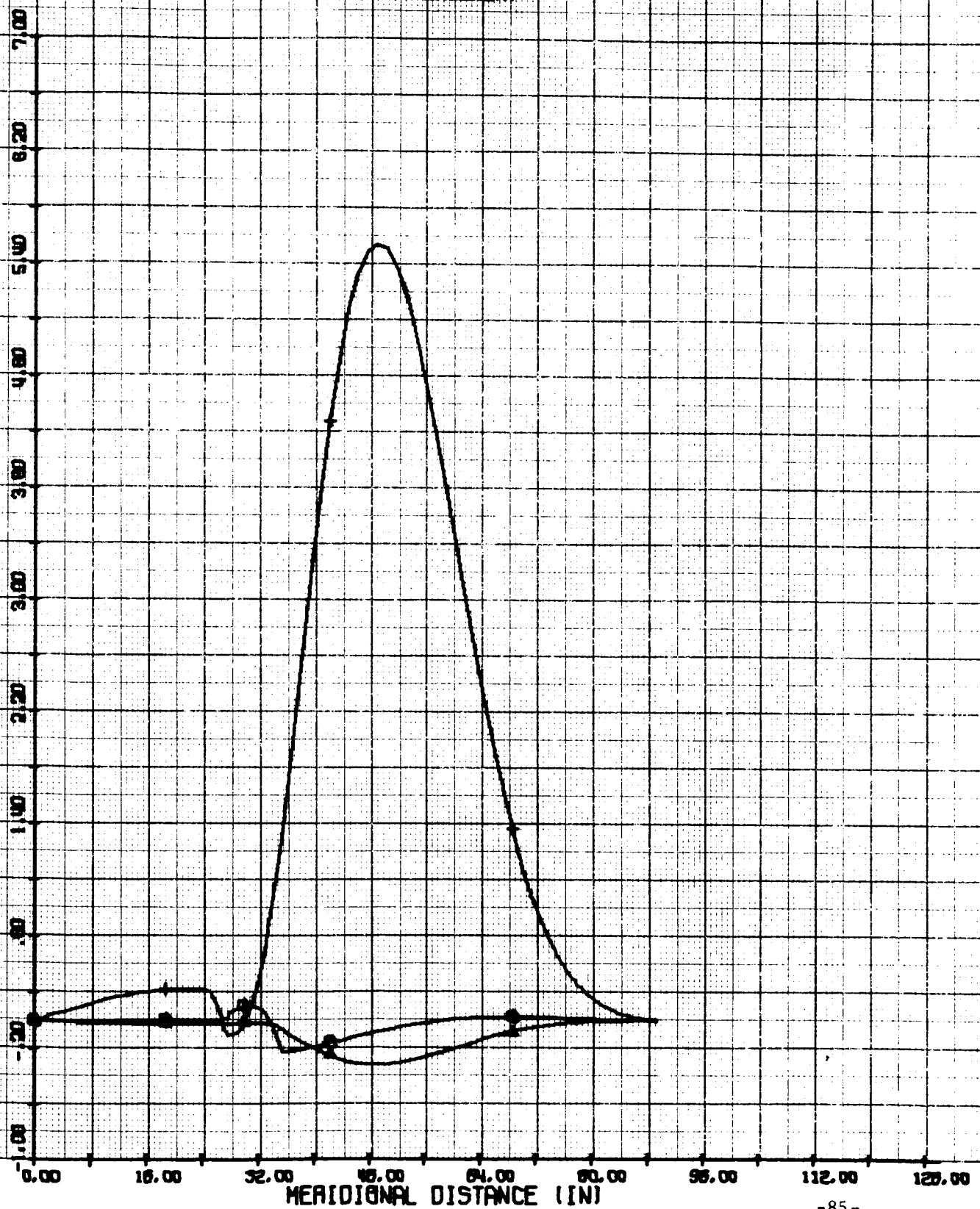


FIGURE 26b

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE 1 (120 IN BASE). OMEGA Z = 107.6 CPS (IN-9)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

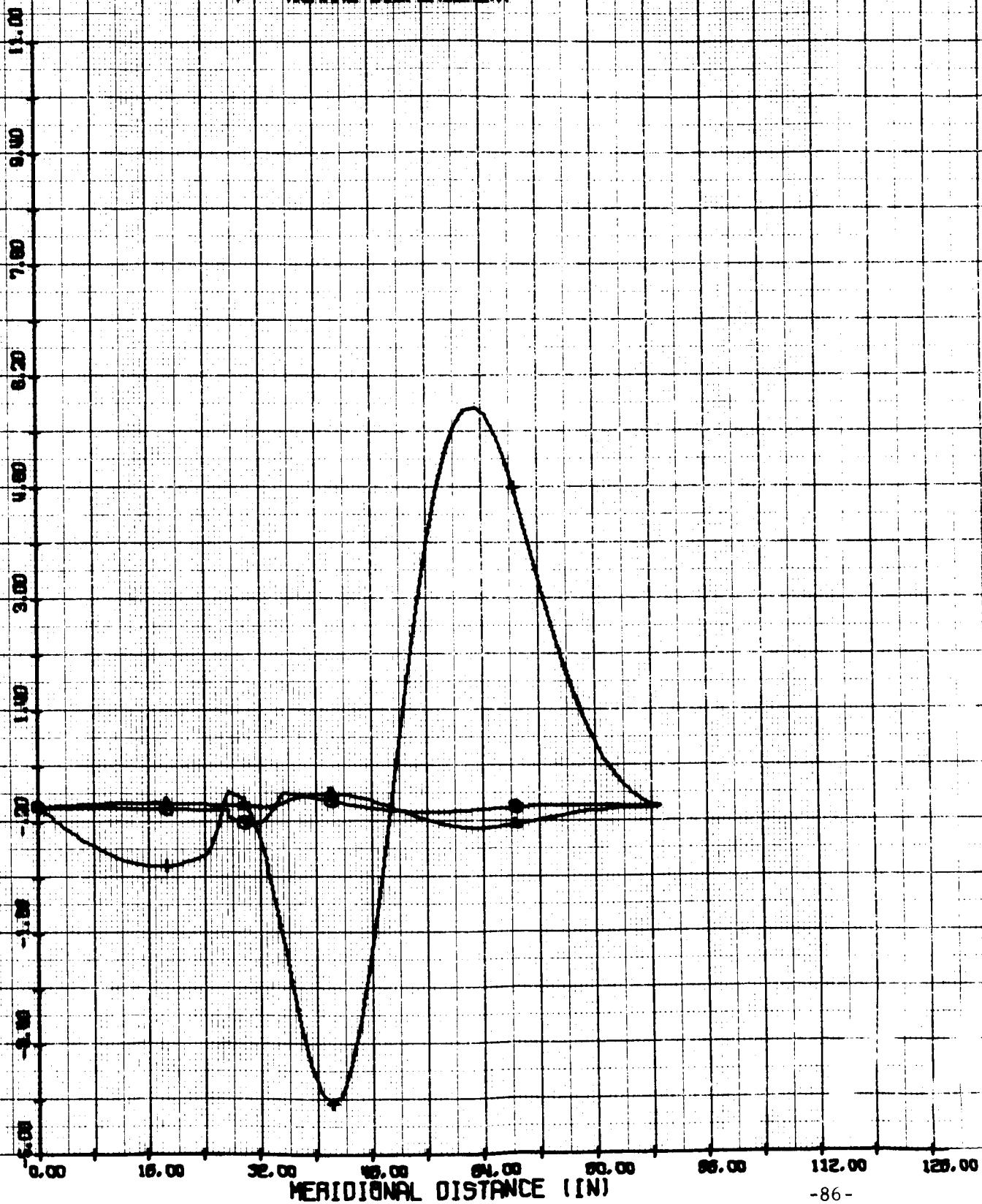


FIGURE 26c

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE 1 (1120 IN BASE) OMEGA 3 = 181.1 CPS (IN/G)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

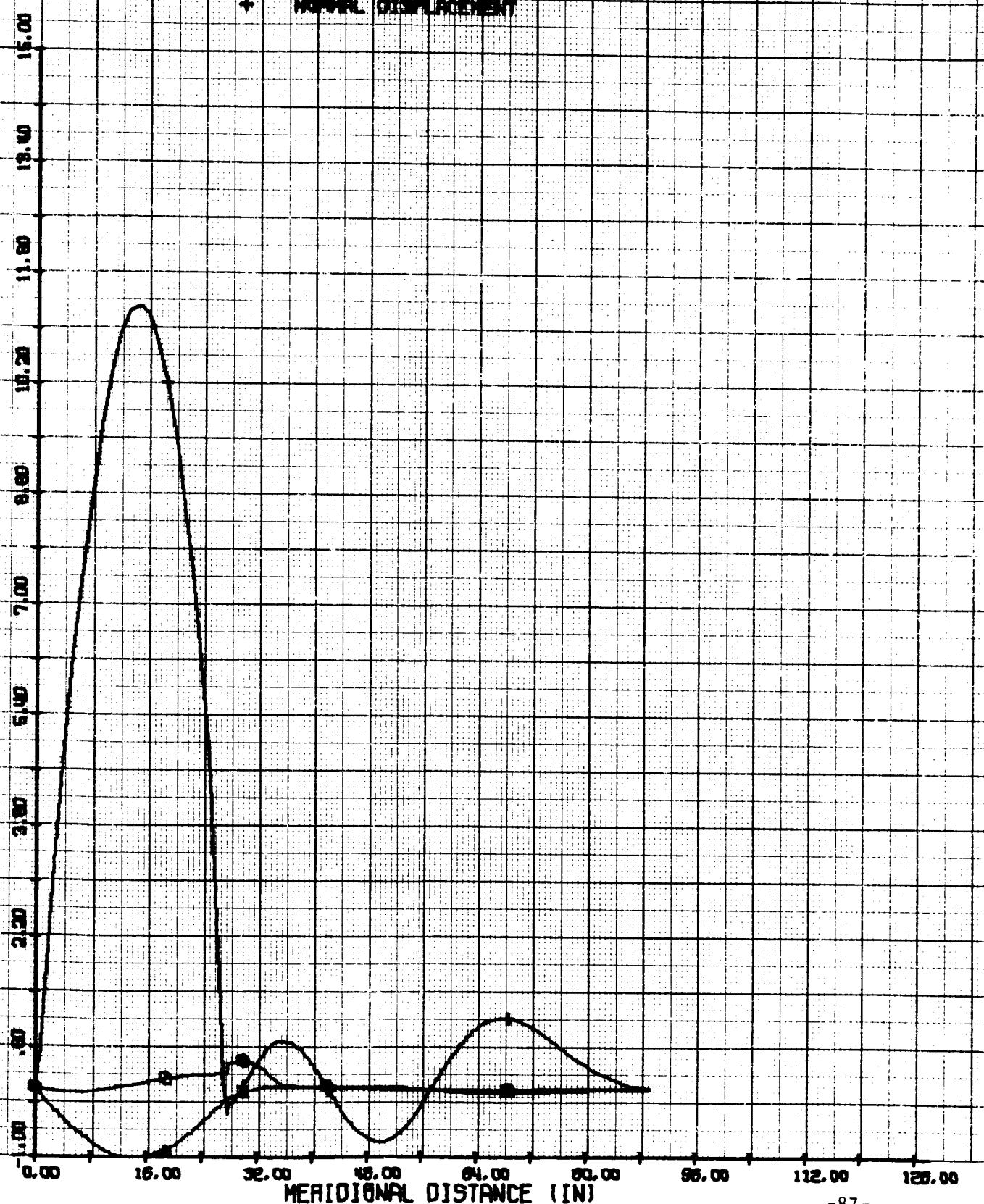


FIGURE 27a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (120 IN BASE) OMEGA 1 = 108.3 CPS (N=10)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

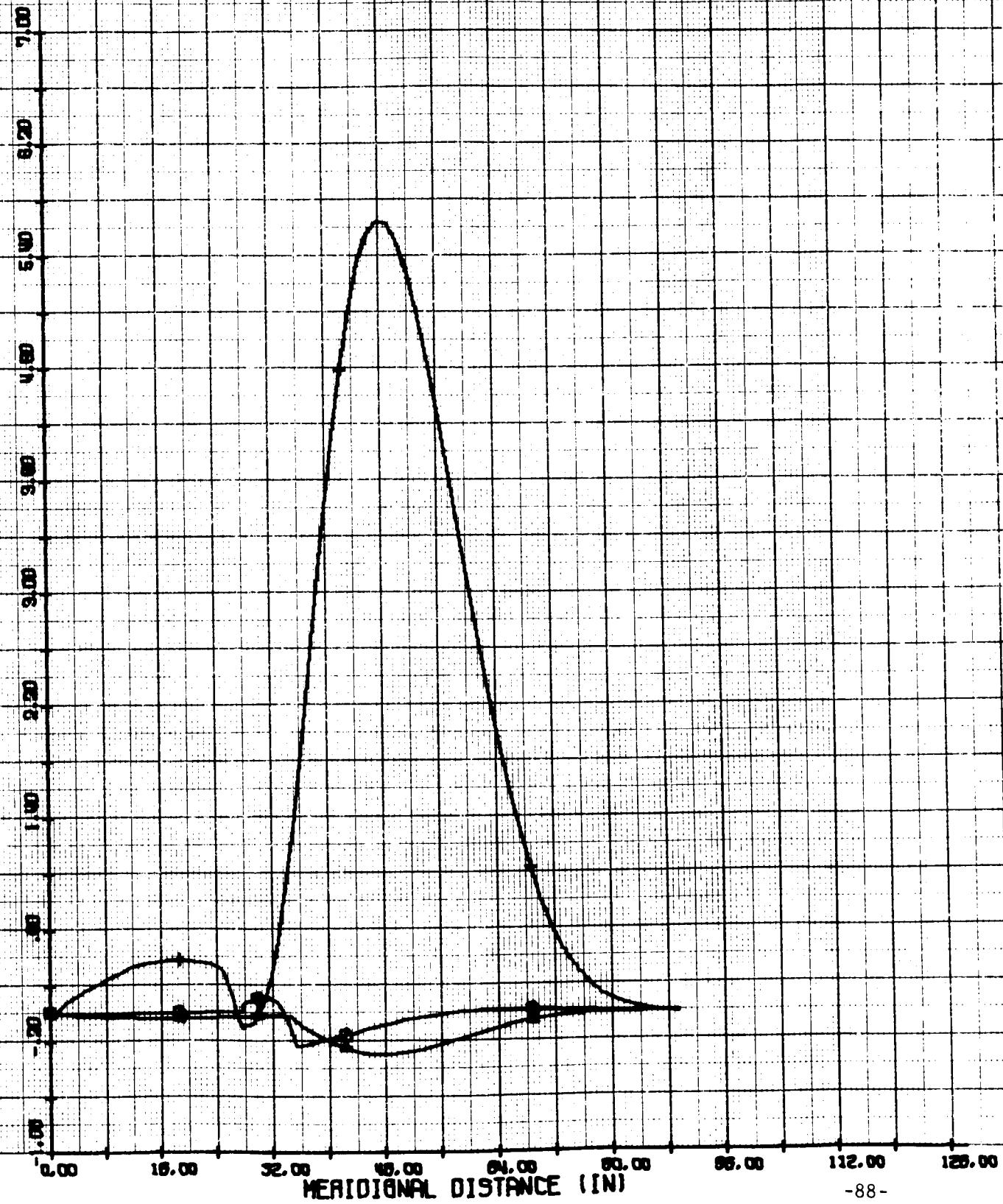


FIGURE 276

VIBRATION MODE DISPLACEMENTS

NRSP TASK 3, CASE 1 (120 IN BASE) OMEGA 2 = 152.5 CPS (N=10)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

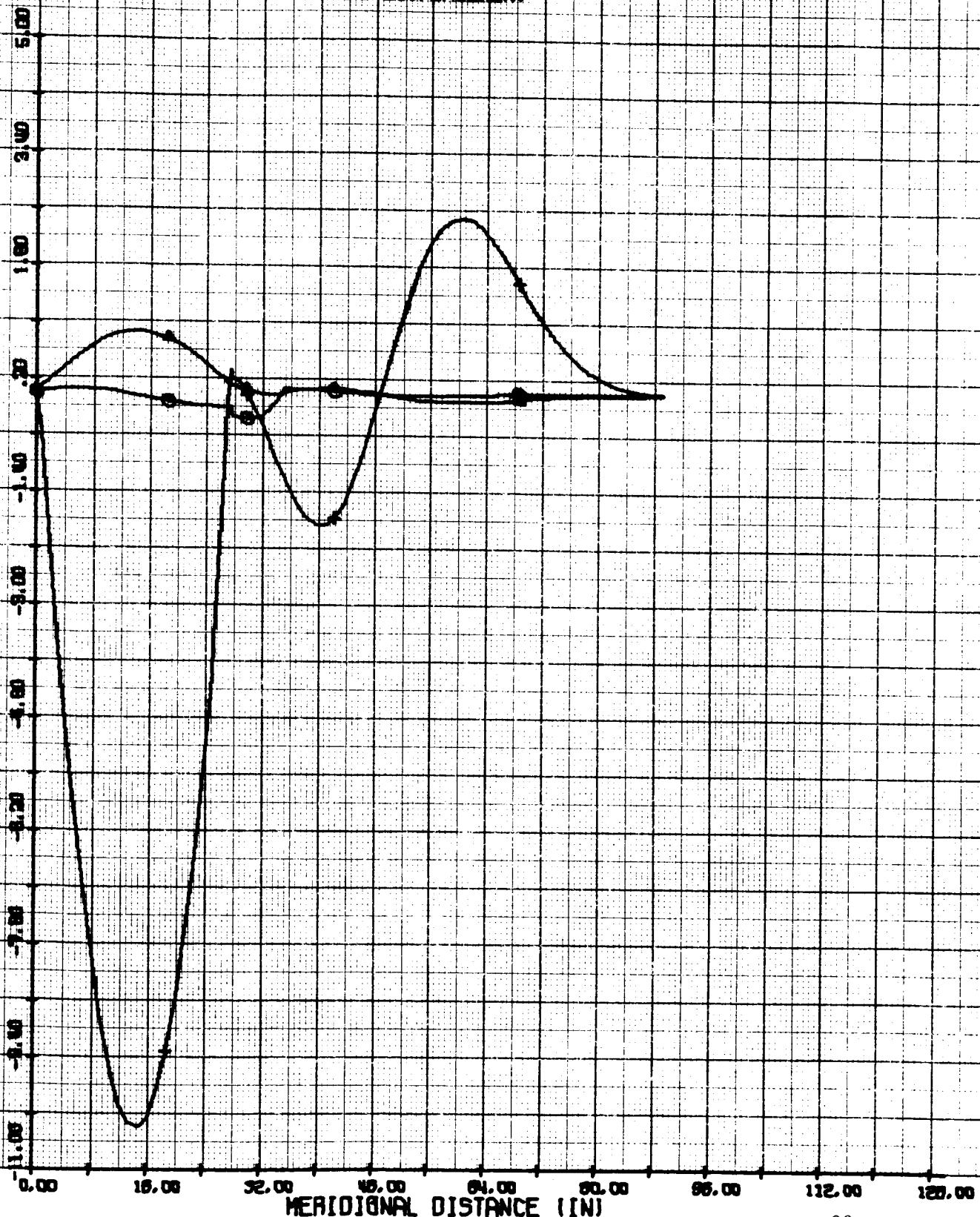


FIGURE 27c

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE I (120 IN BASE) OMEGA 3 = 170.0 CPS (N=10)

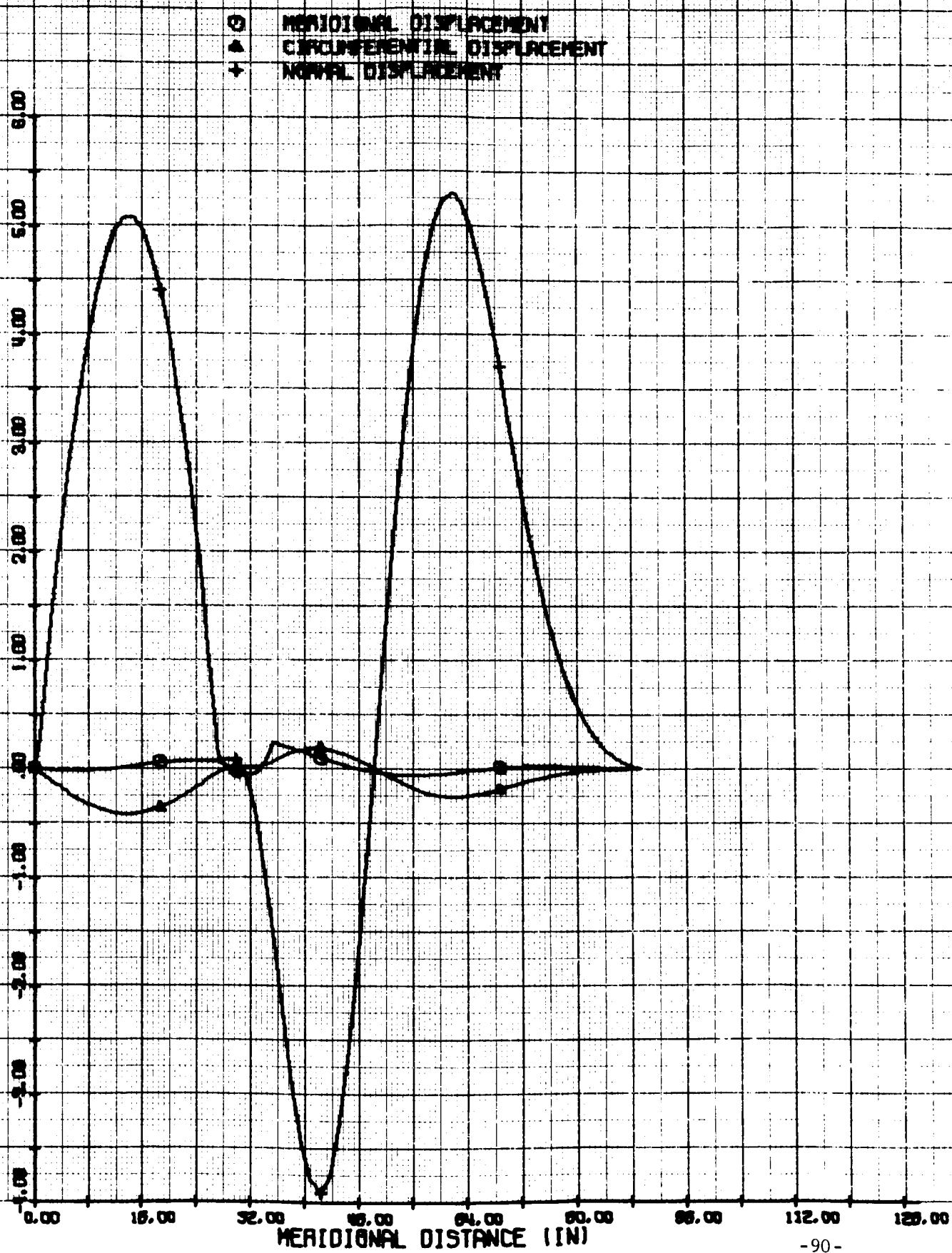


FIGURE 28a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE I (165 IN BASE). OMEGA 1 = 18.15 CPS (N=0)

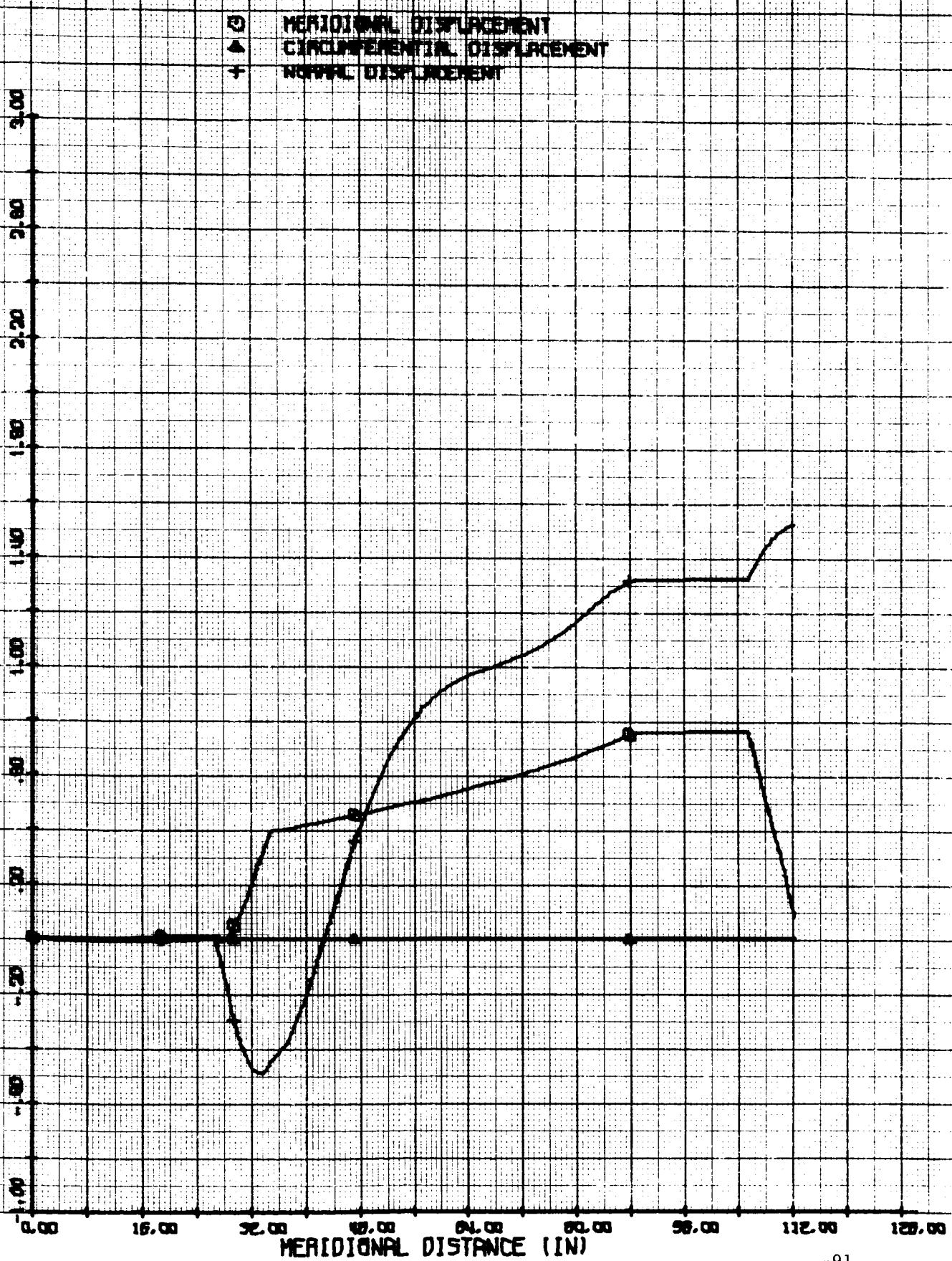


FIGURE 28b

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE I (165 IN BREE), $\Omega_{MGR} 2 = 67.03$ CPS ($N=0$)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

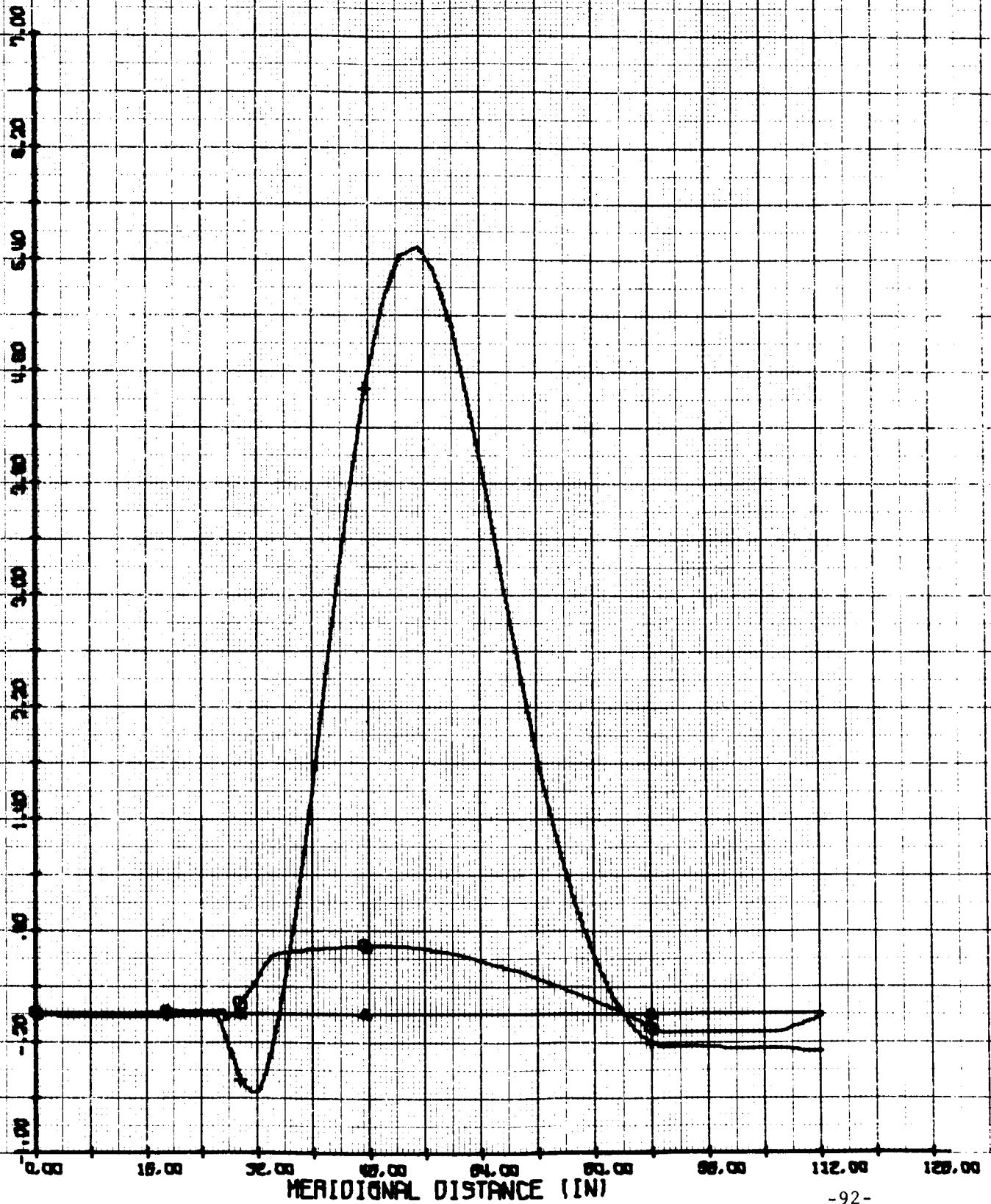


FIGURE 28c

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (165 IN BASED). OMEGA 3 = 76.34 CPS (N=0)

- ③ MERIDIONAL DISPLACEMENT
- ④ CIRCUMFERENTIAL DISPLACEMENT
- ⑤ NORMAL DISPLACEMENT

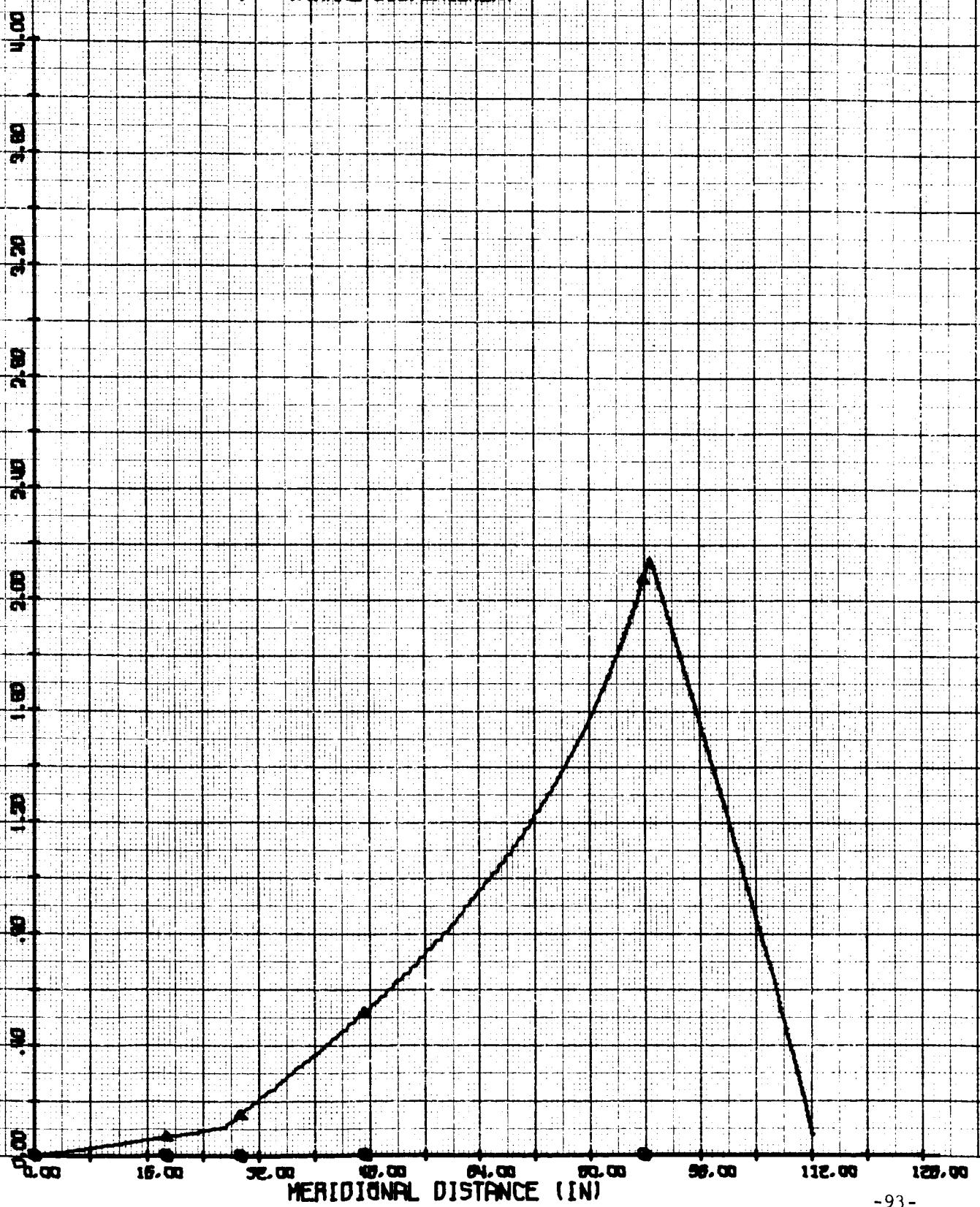


FIGURE 29a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (165 IN BASE). OMEGA I = 18.23 CPS (IN=1)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + RADIAL DISPLACEMENT

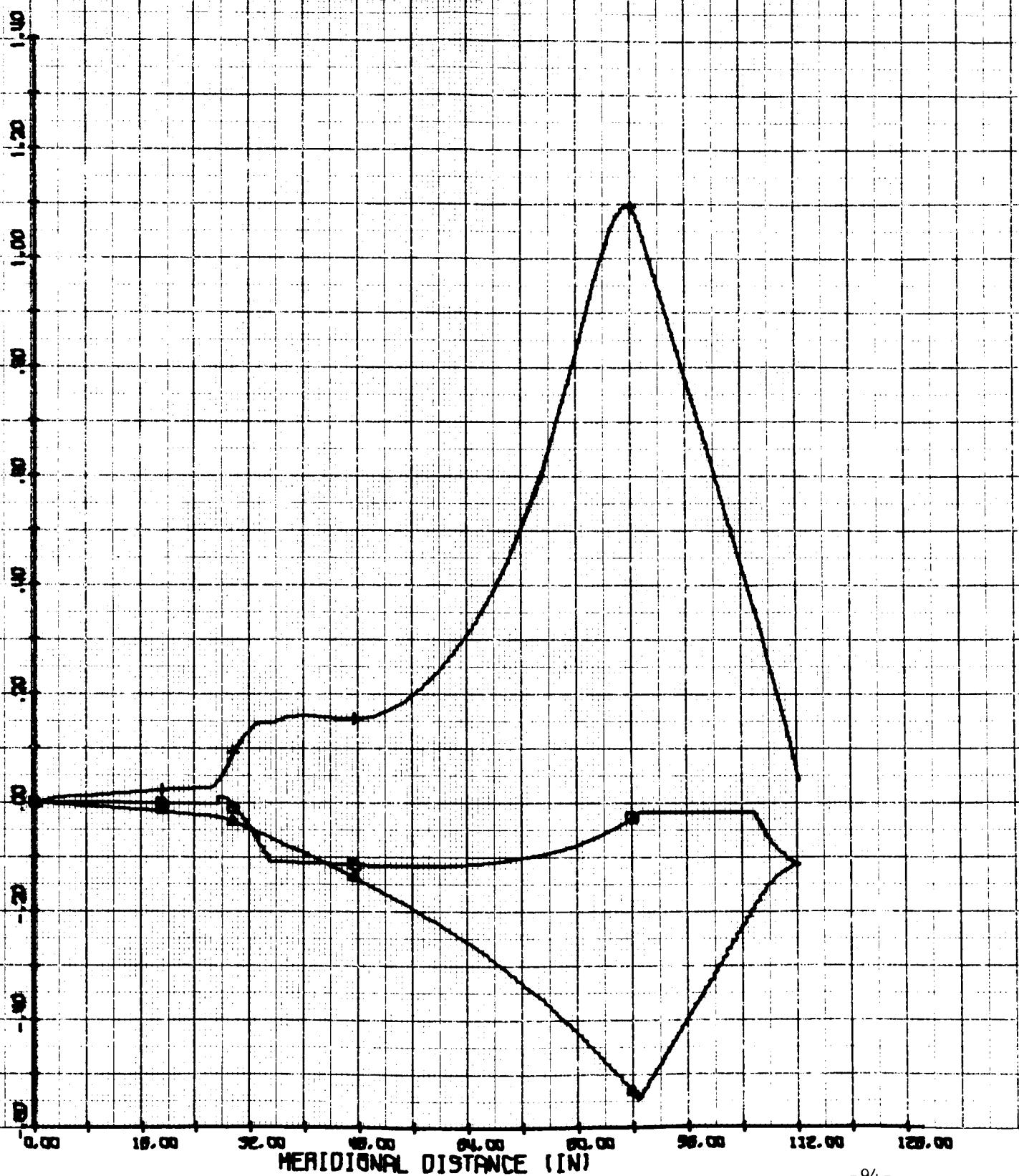


FIGURE 296

VIBRATION MODE DISPLACEMENTS

NPSR TASK 3. CASE I (165 IN BASE). OMEGA 2 = 41.07 CPS (N=1)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

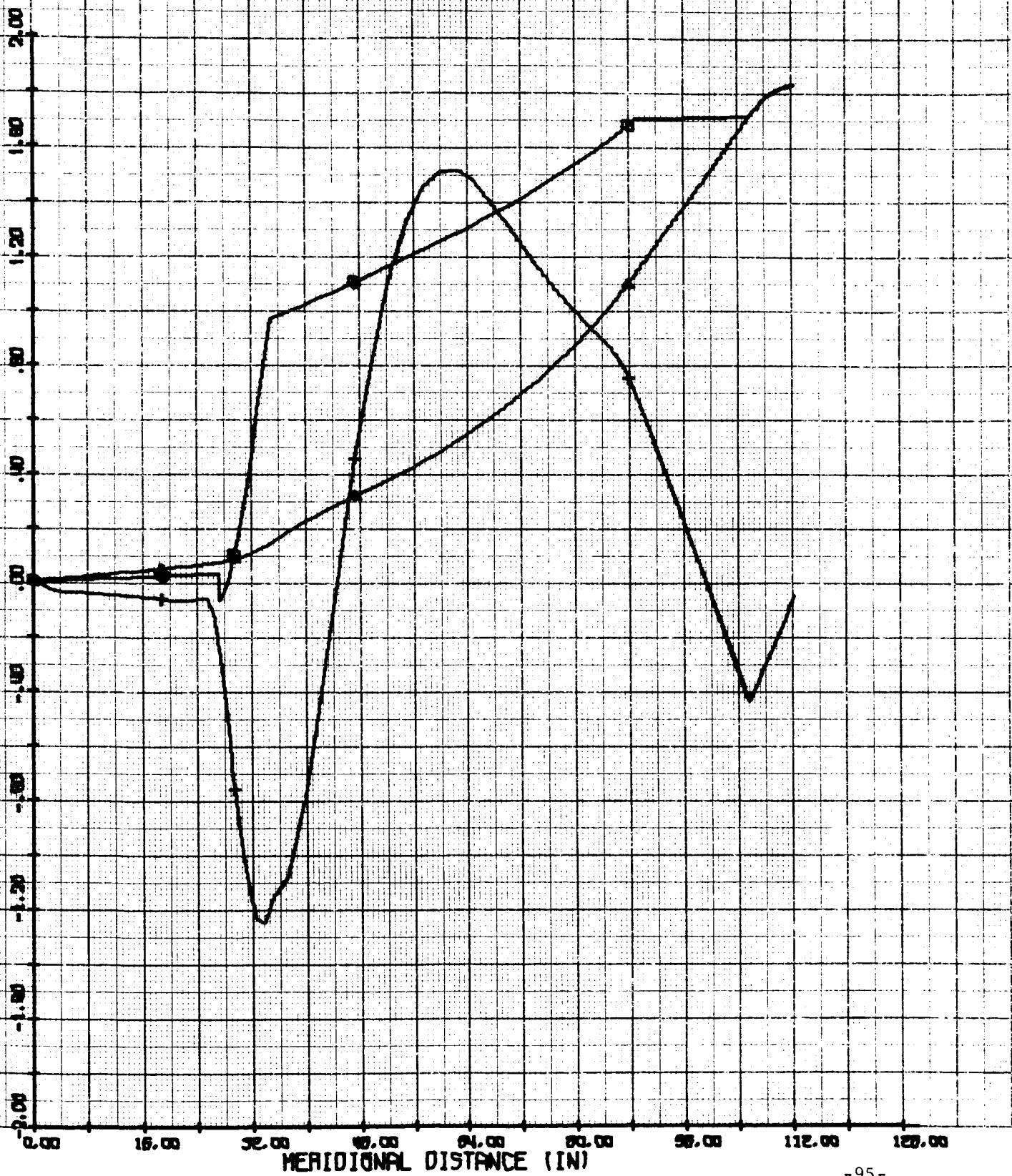


FIGURE 29C

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE I (165 IN BASE), OMEGA 3 = 63.18 CPS (N=1)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

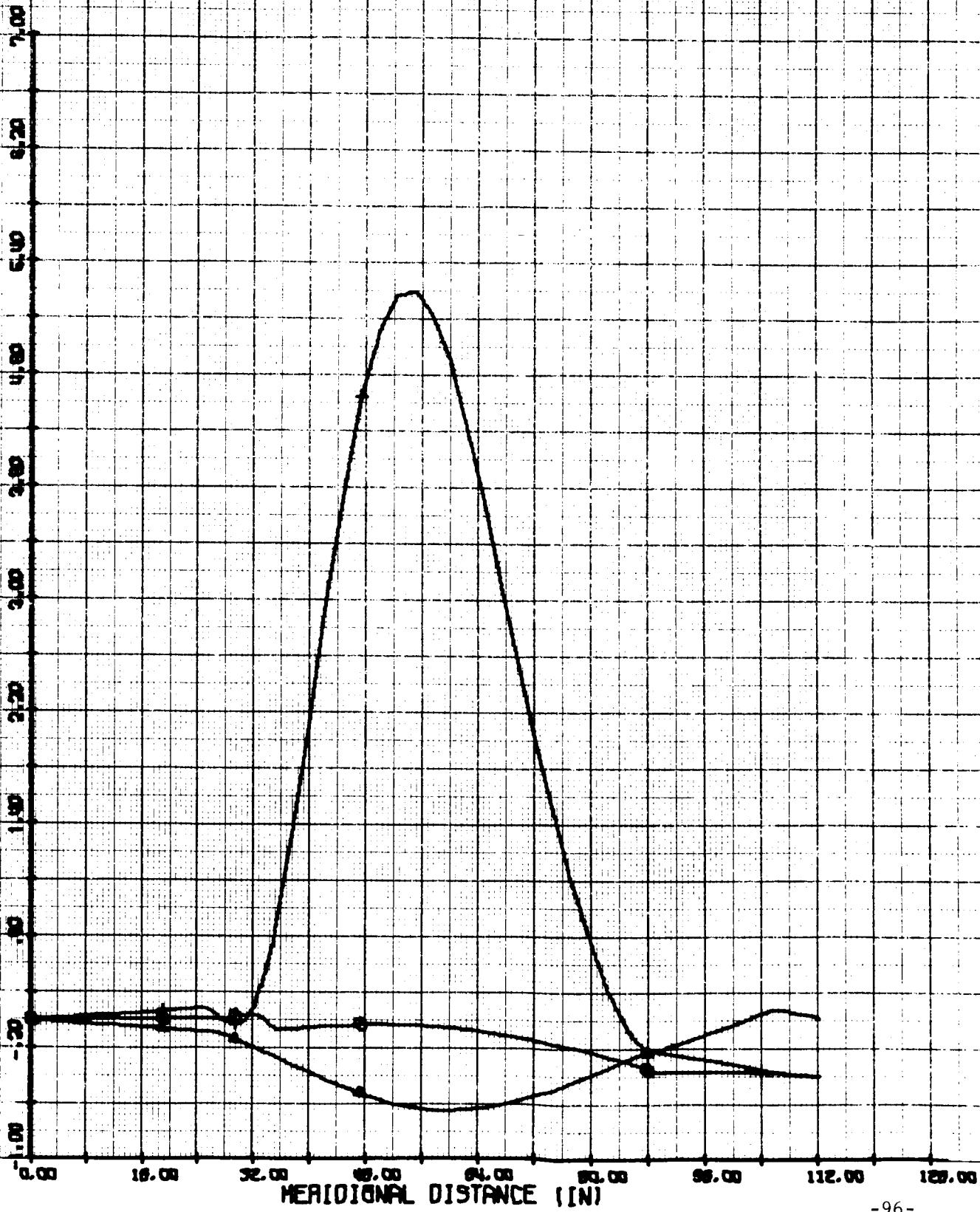


FIGURE 30a
VIBRATION MODE DISPLACEMENTS
NASA TASK 3. CASE I (165 IN BASE). OMEGA 1 = 48.83 CPS (N=2)

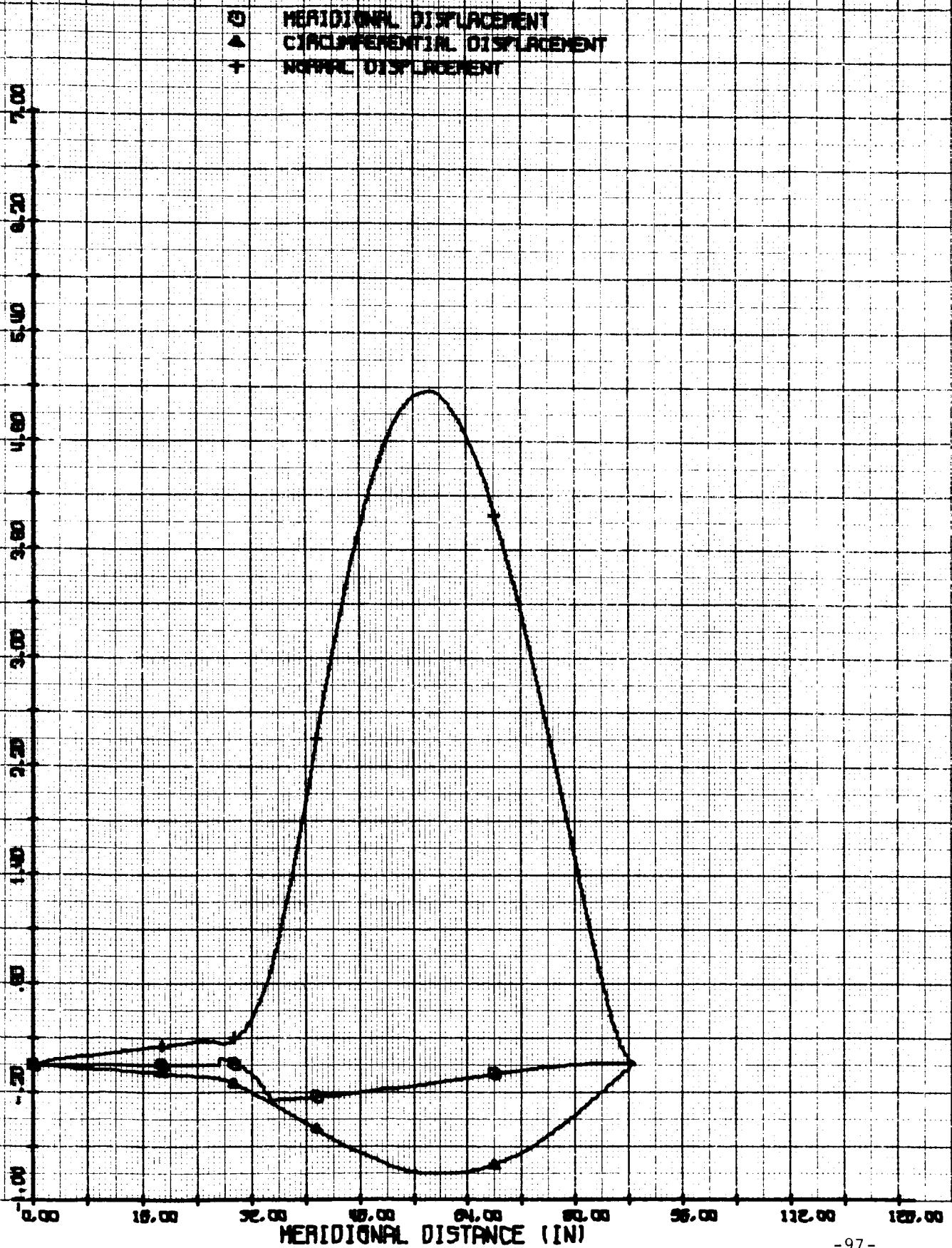


FIGURE 30b

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (1165 IN BASE). OMEGA Z = 82.55 CPS (N=2)

- MERIDIONAL DISPLACEMENT
- × CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

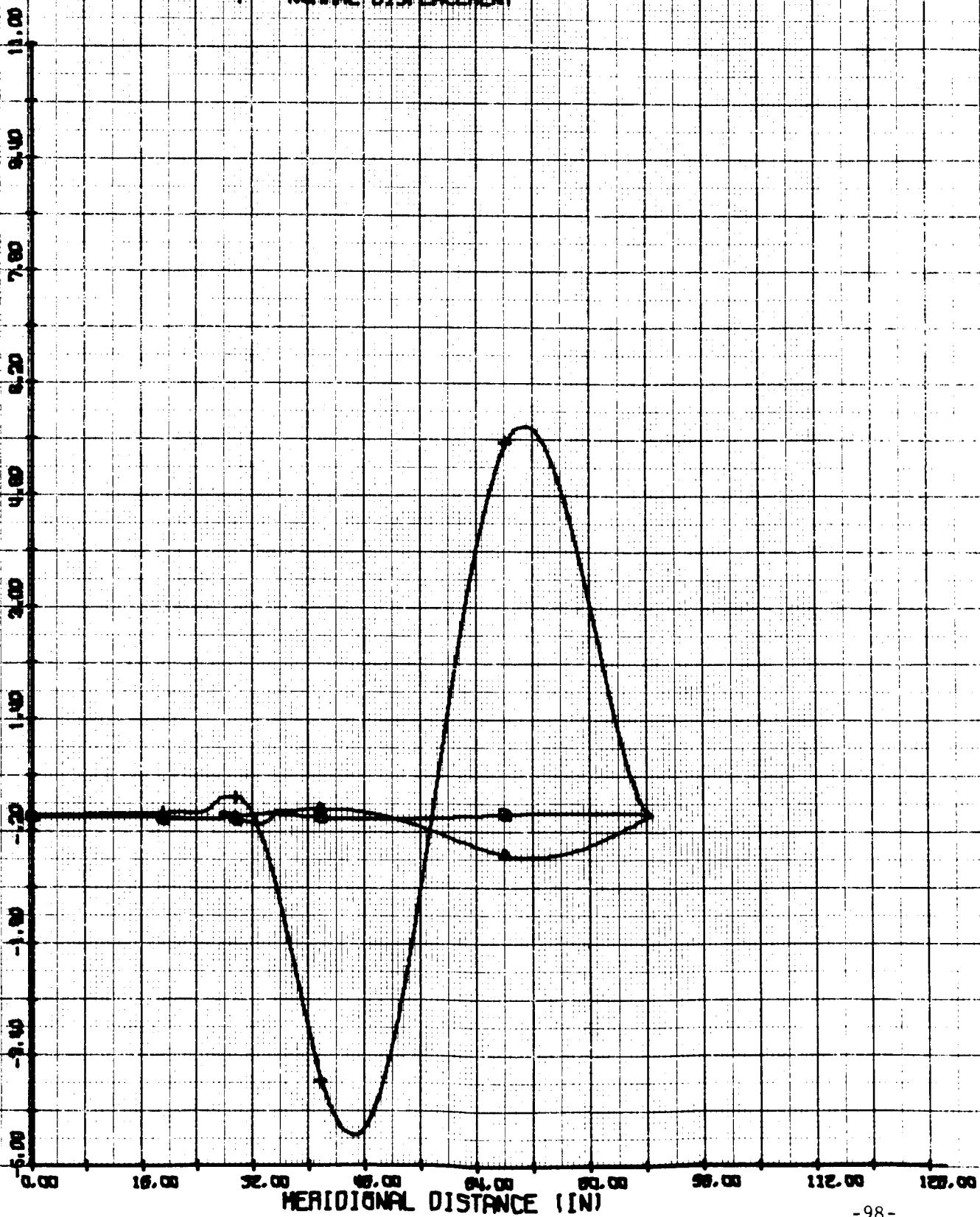


FIGURE 30c

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (165 IN BASE). OMEGA 3 = 117.1 CPS (N=2)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

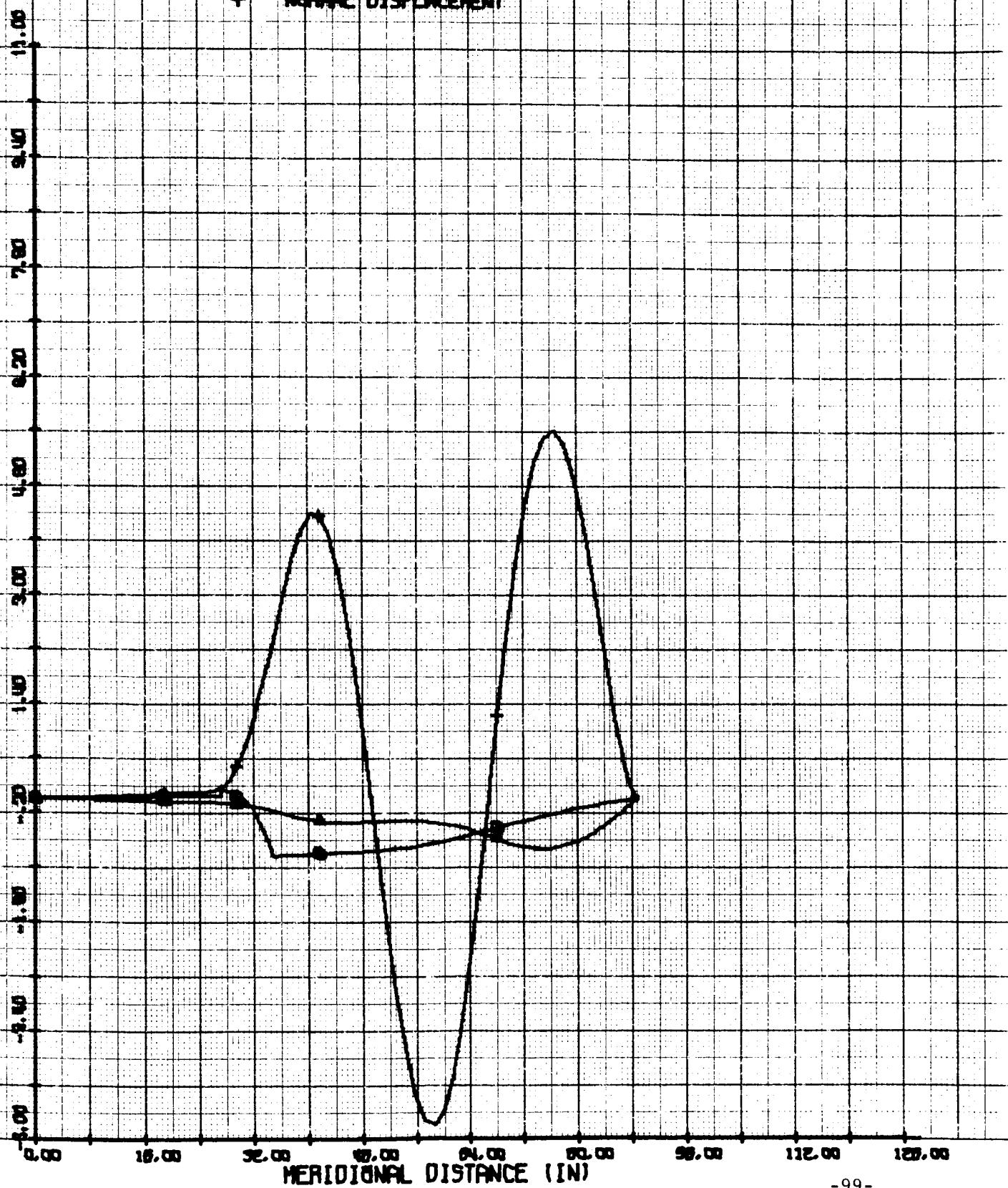


FIGURE 31.a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (1165 IN BASE). OMEGA 1 = 39.14 CPS (N=3)

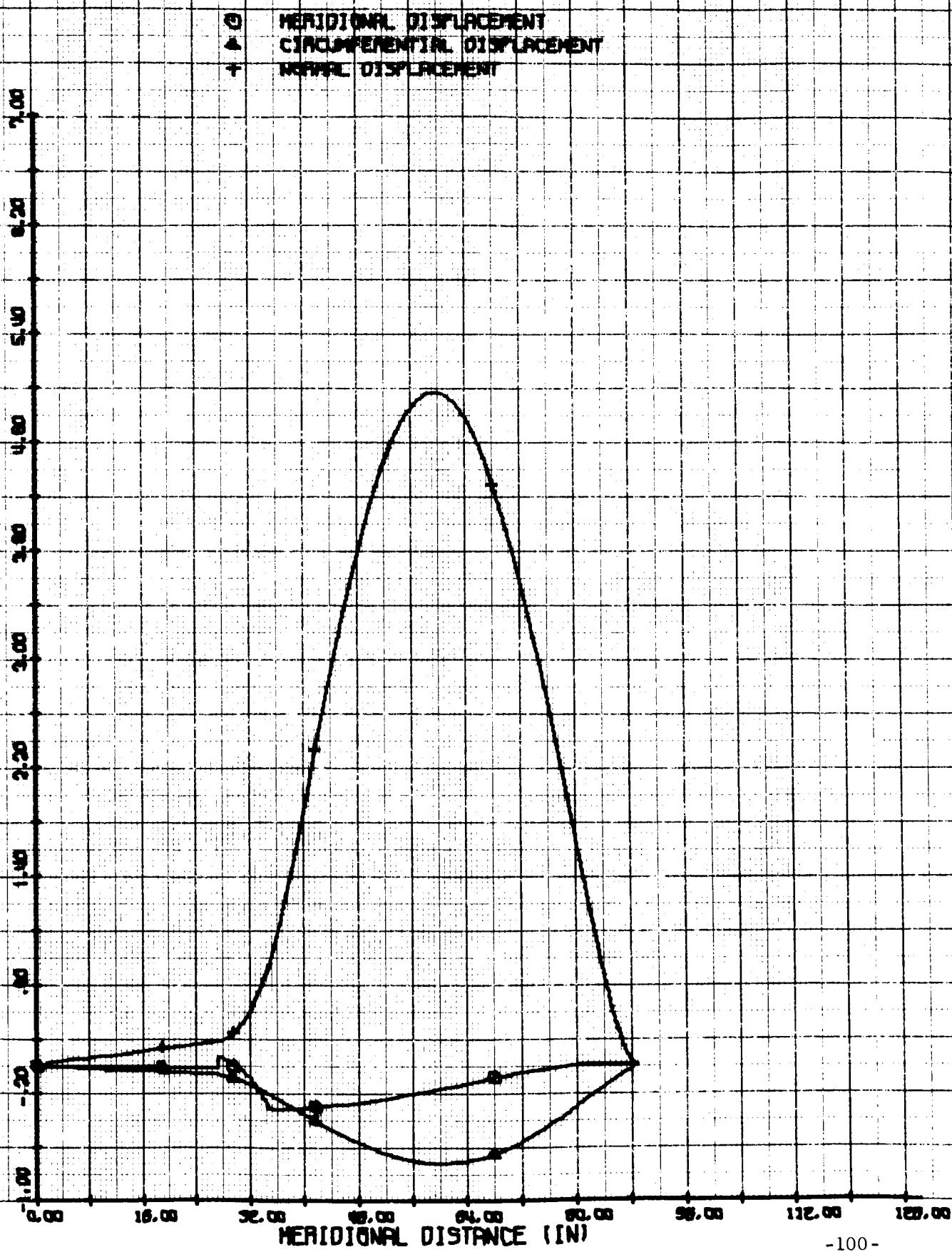


FIGURE 31b

VIBRATION MODE DISPLACEMENTS

NASA TASK 3 - CASE 1 (165 IN BASE). OMEGA 2 = 78.92 CPS (N=3)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

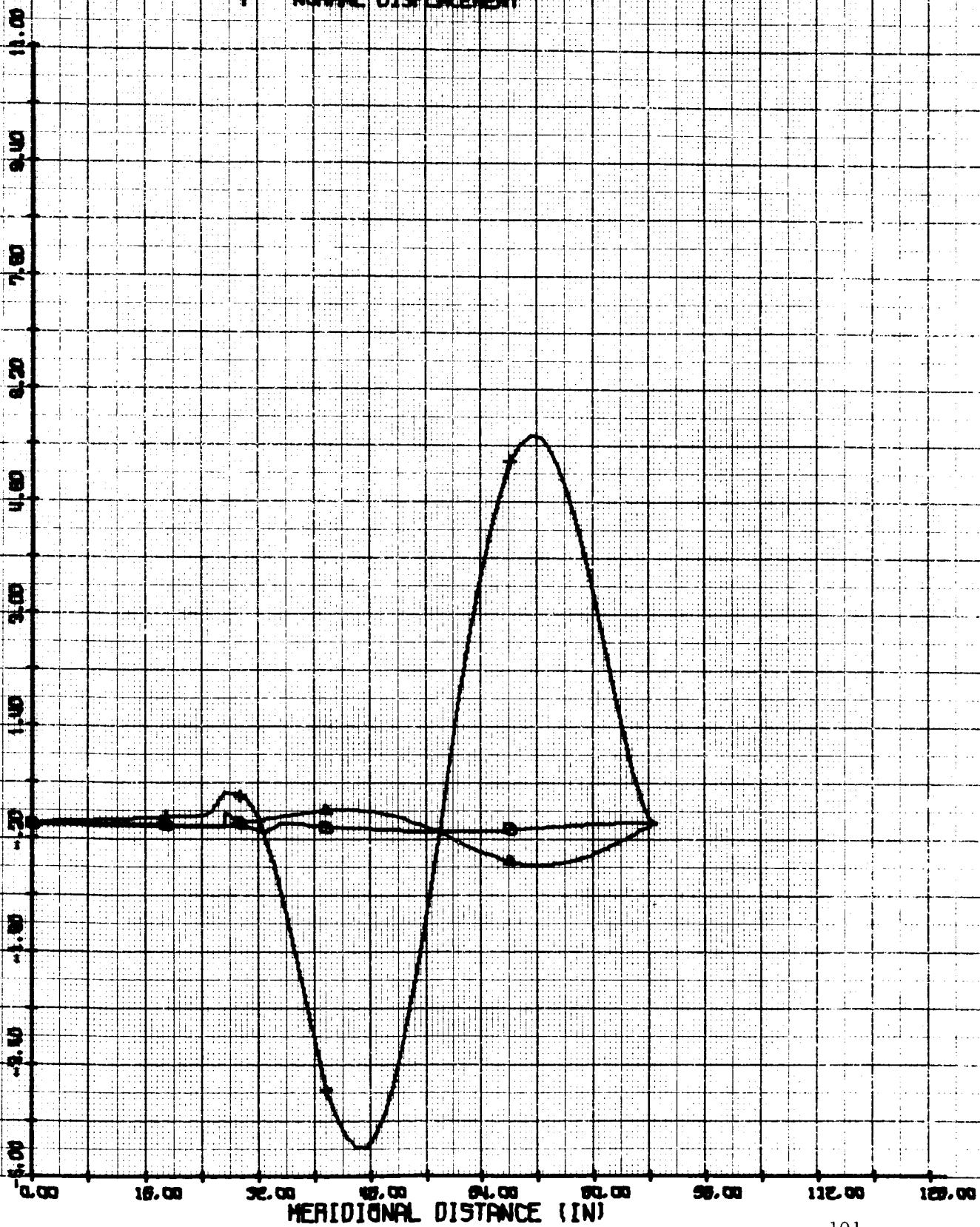


FIGURE 3.C

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (165 IN BASE). OMEGA 3 = 119.9 CPS (N=3)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

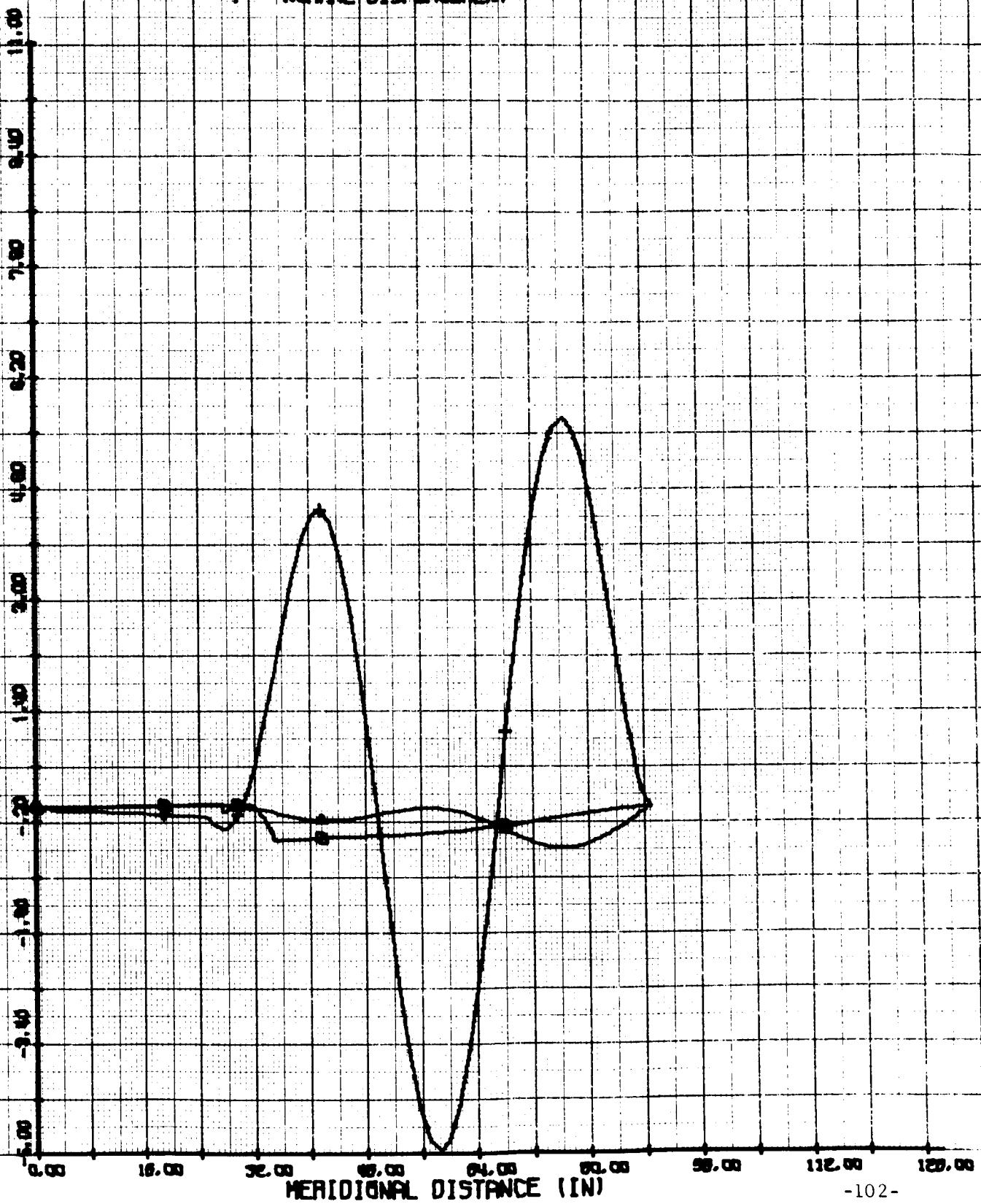


FIGURE 32a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE 1 (165 IN BASE). OMEGA 1 = 38.32 CPS (IN=4)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

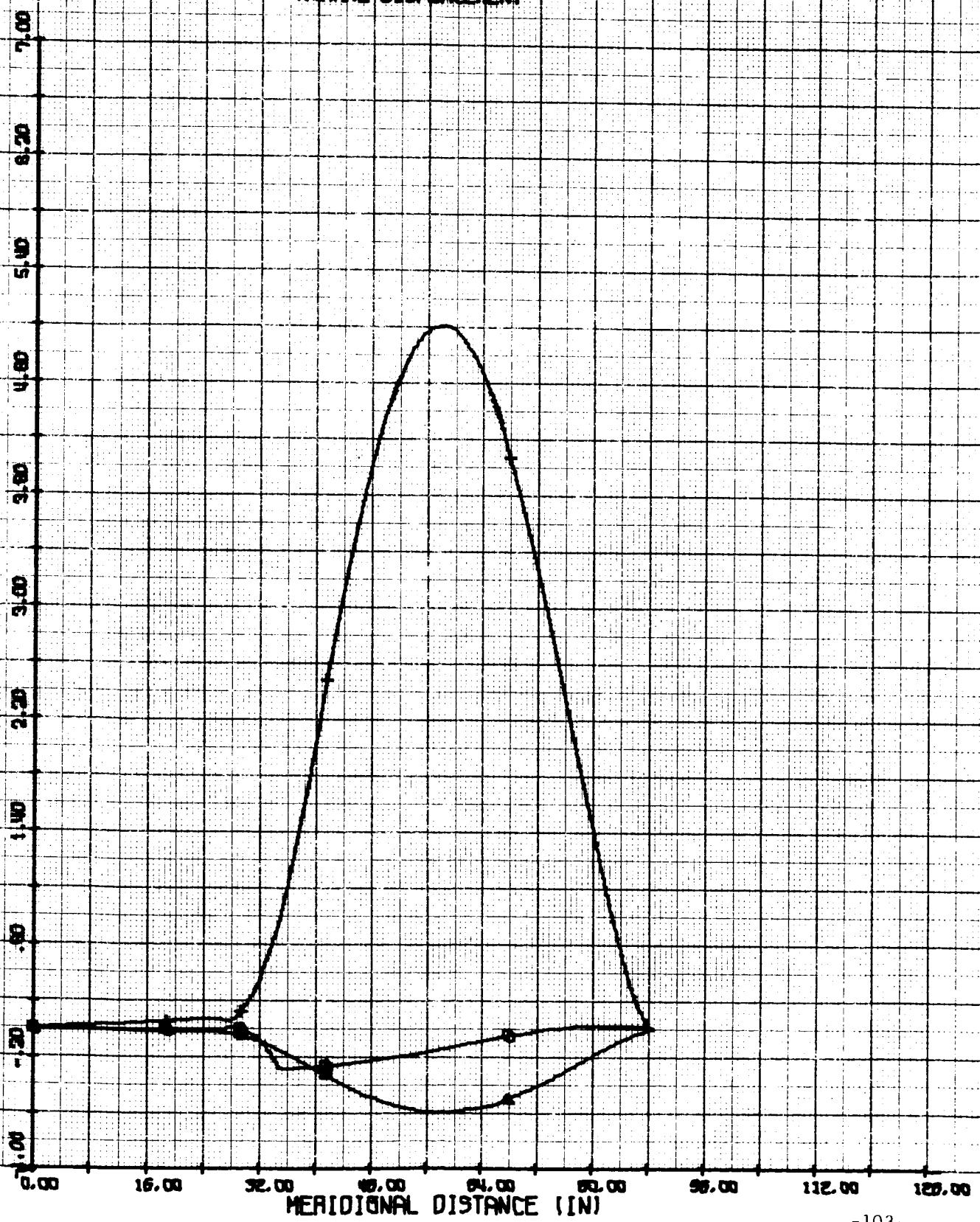


FIGURE 32b

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (165 IN BASE). OMEGA 2 = 79.72 CPS (IN=4)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

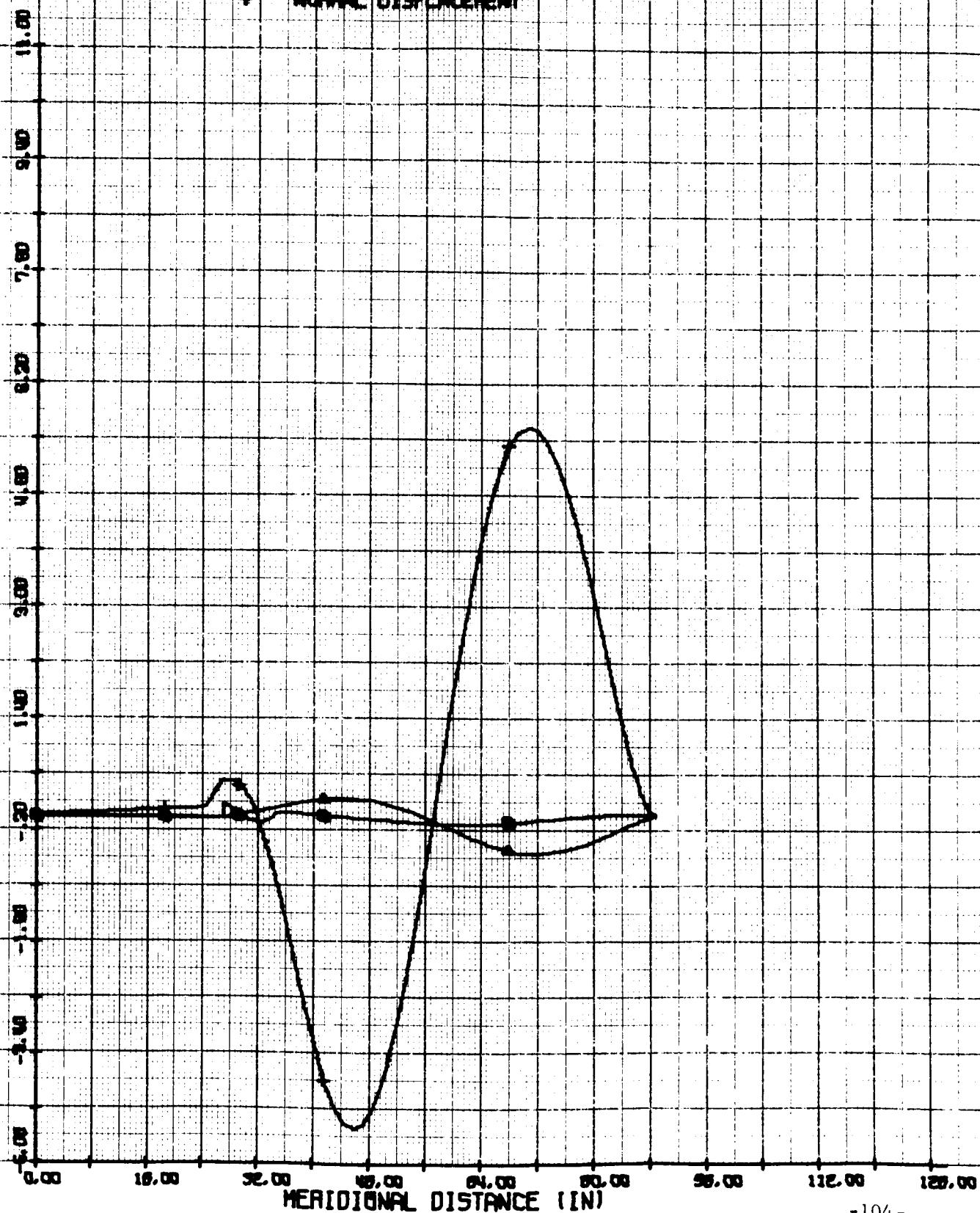


FIGURE 32c

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE 1 (165 IN BASE), OMEGA 3 = 125.0 CPS (N=4)

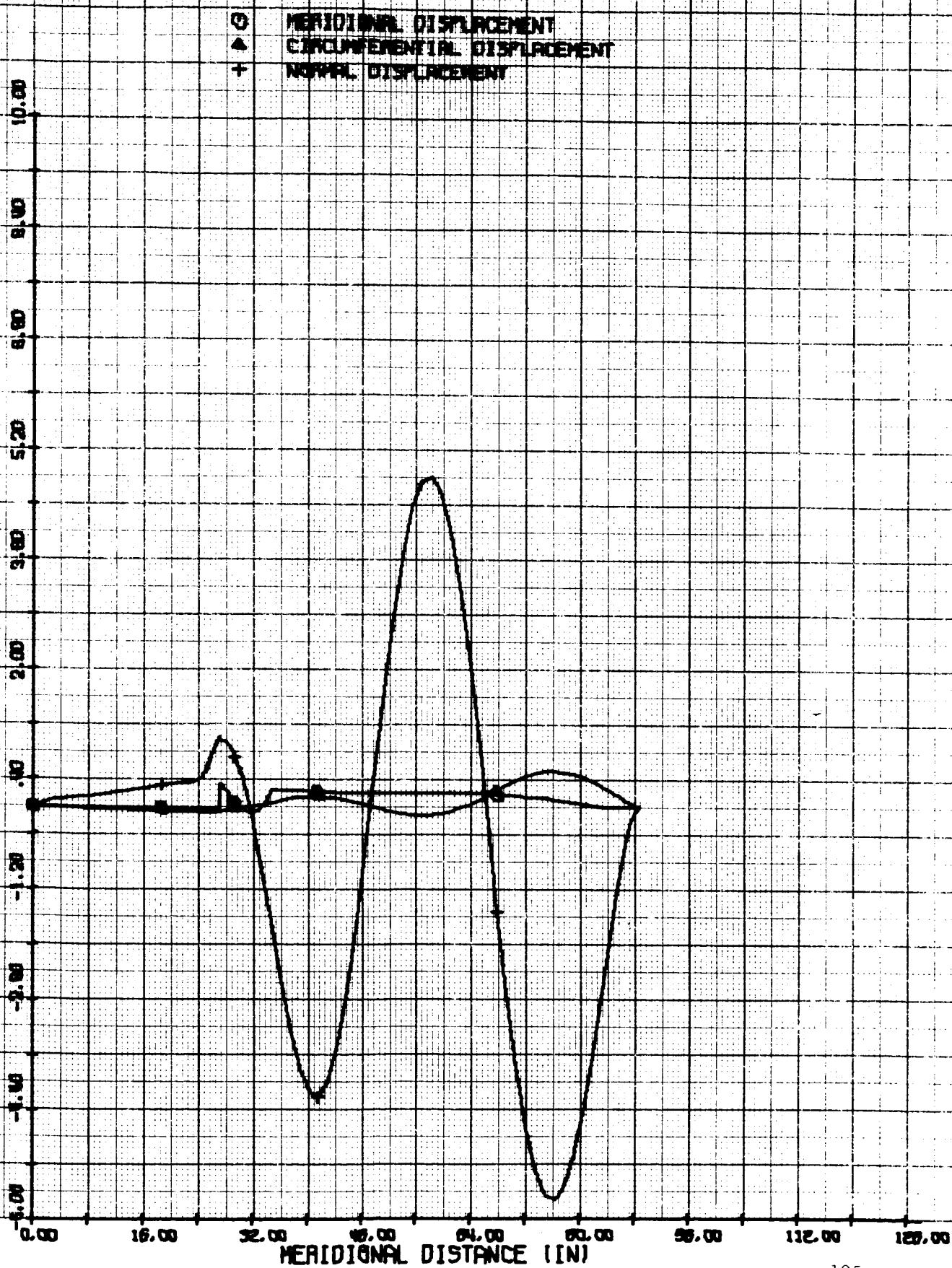


FIGURE 33a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (165 IN BASE). OMEGA 1 = 43.92 CPS (IN/S)

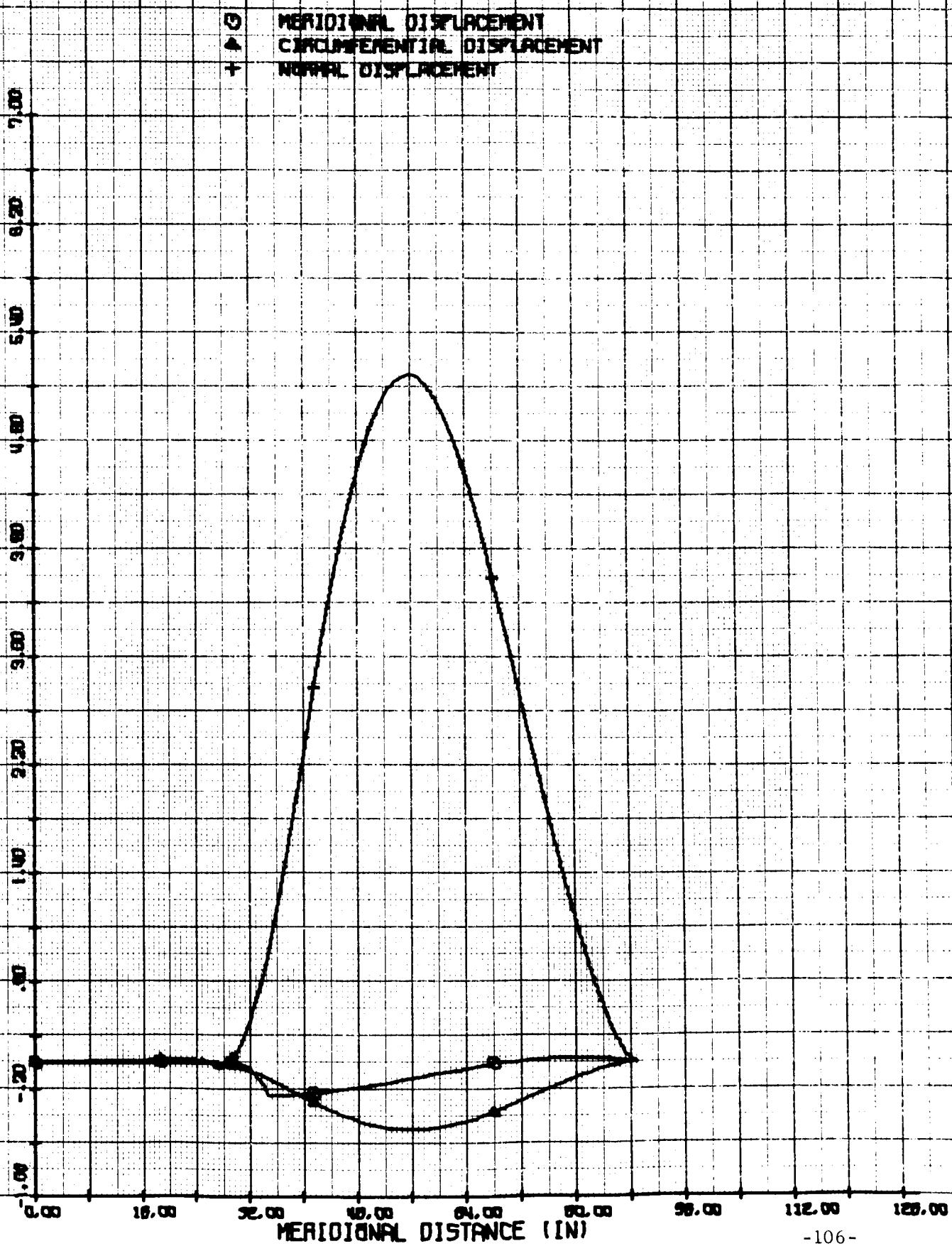


FIGURE 31b

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE 1 (165 IN BREEZE). OMEGA 2 = 86.24 CPS (N=5)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

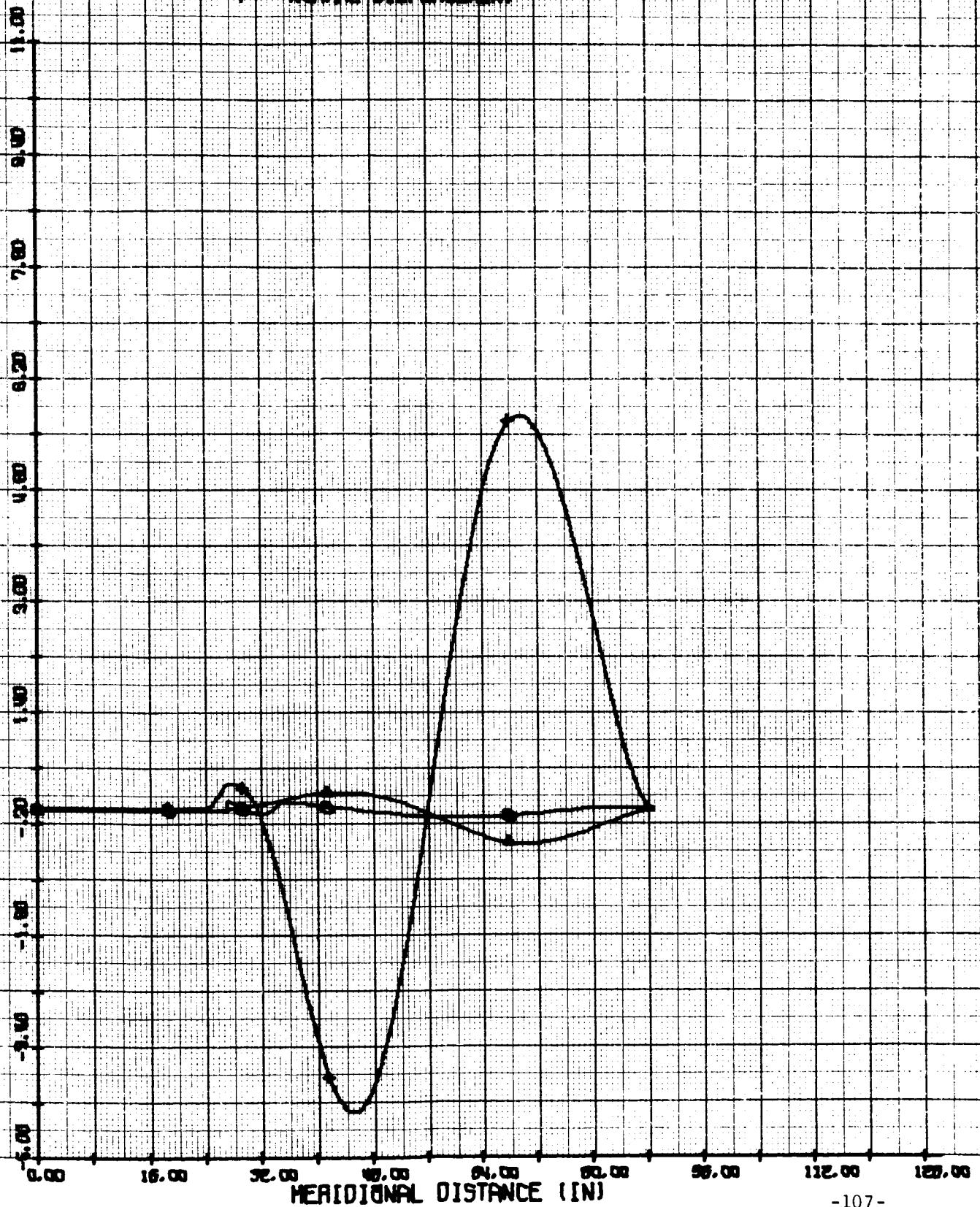


FIGURE 3Bc

VIBRATION MODE DISPLACEMENTS

NRSA TASK 3. CASE I (165 IN BASE). OMEGA 3 = 194.5 CPS (N=5)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

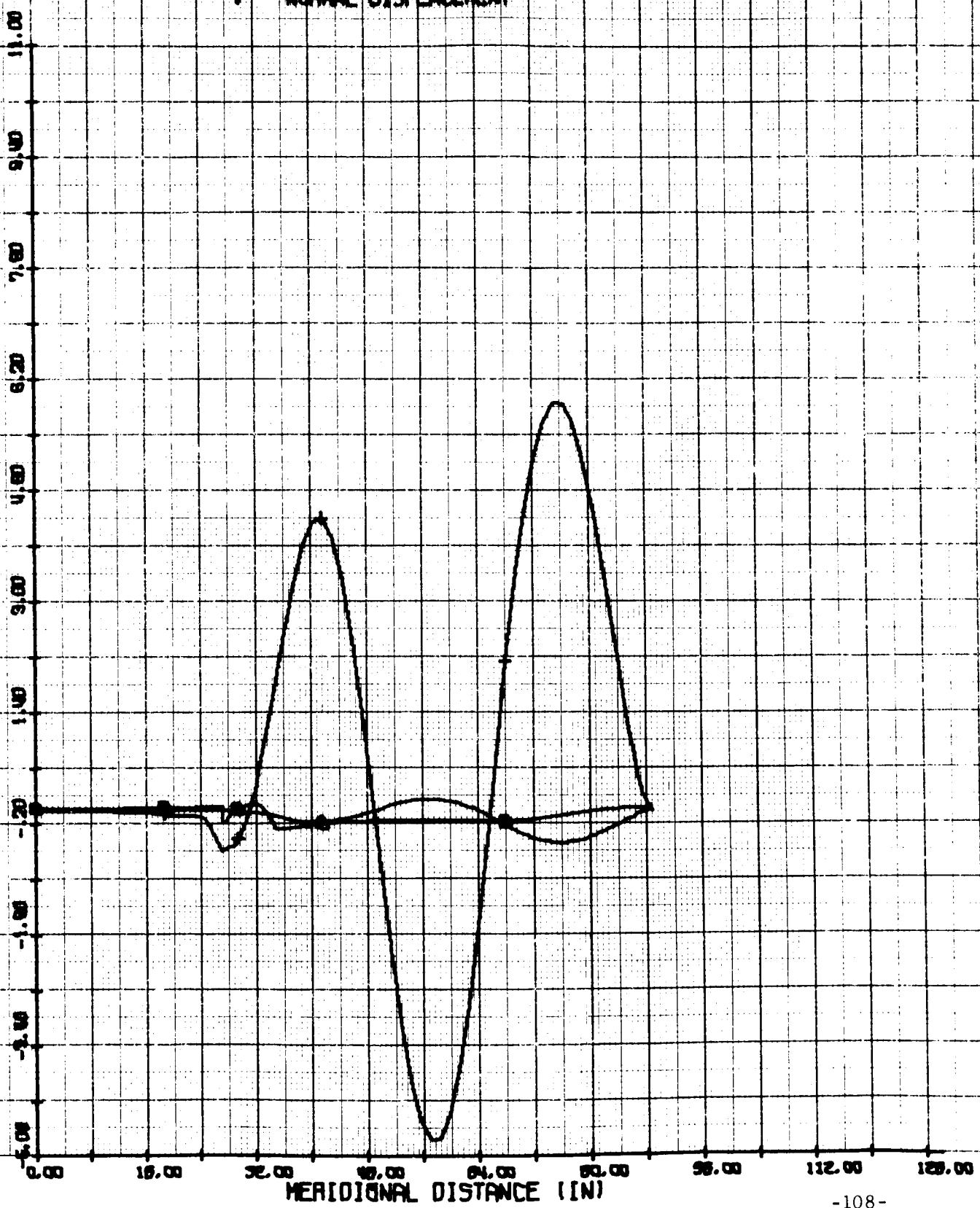


FIGURE 34a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE 1 (165 IN RIGID), OMEGA 1 = 58.32 CPS (IN=6)

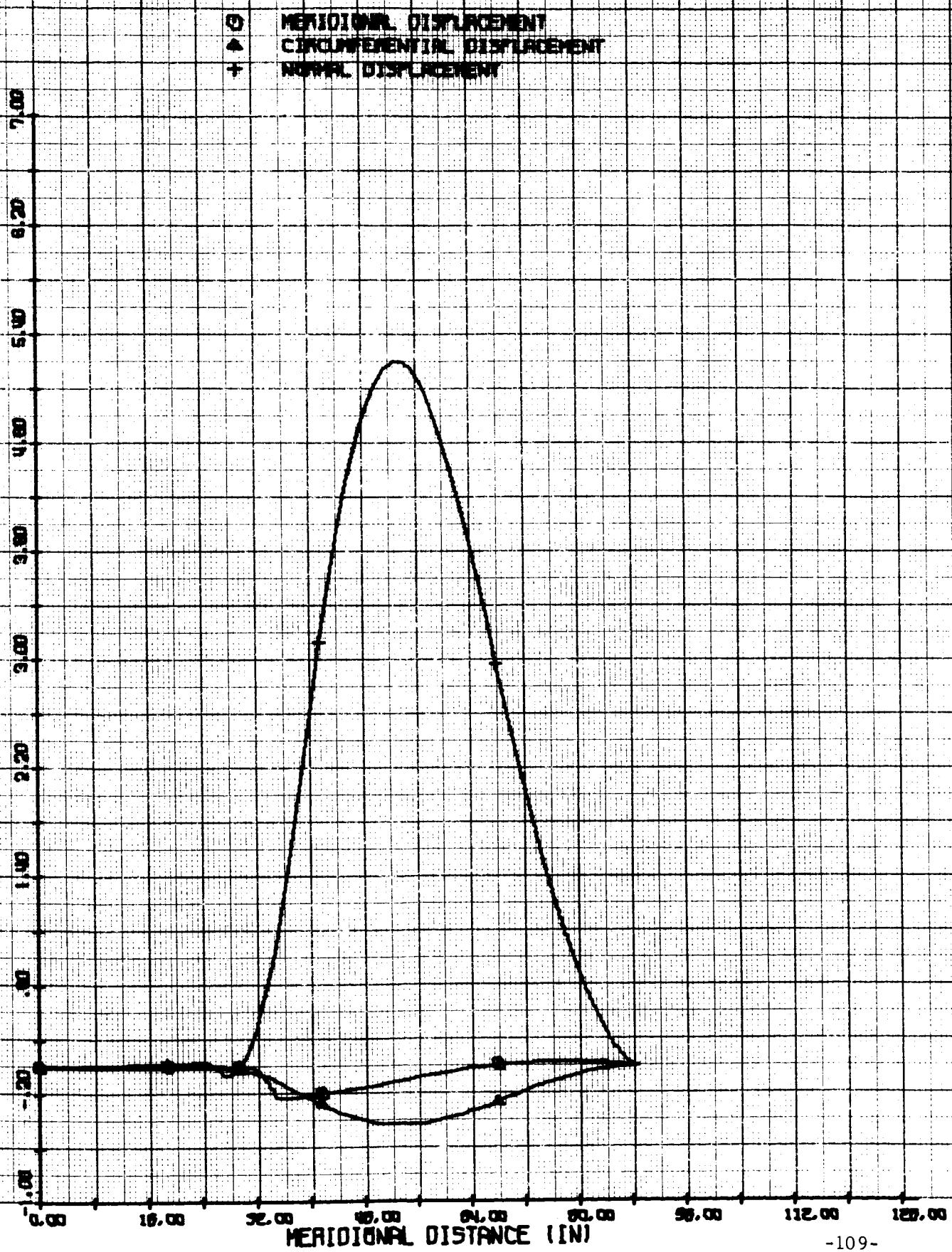


FIGURE 34b

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (1165 IN BASE). OMEGA 2 = 97.63 CPS (N=6)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

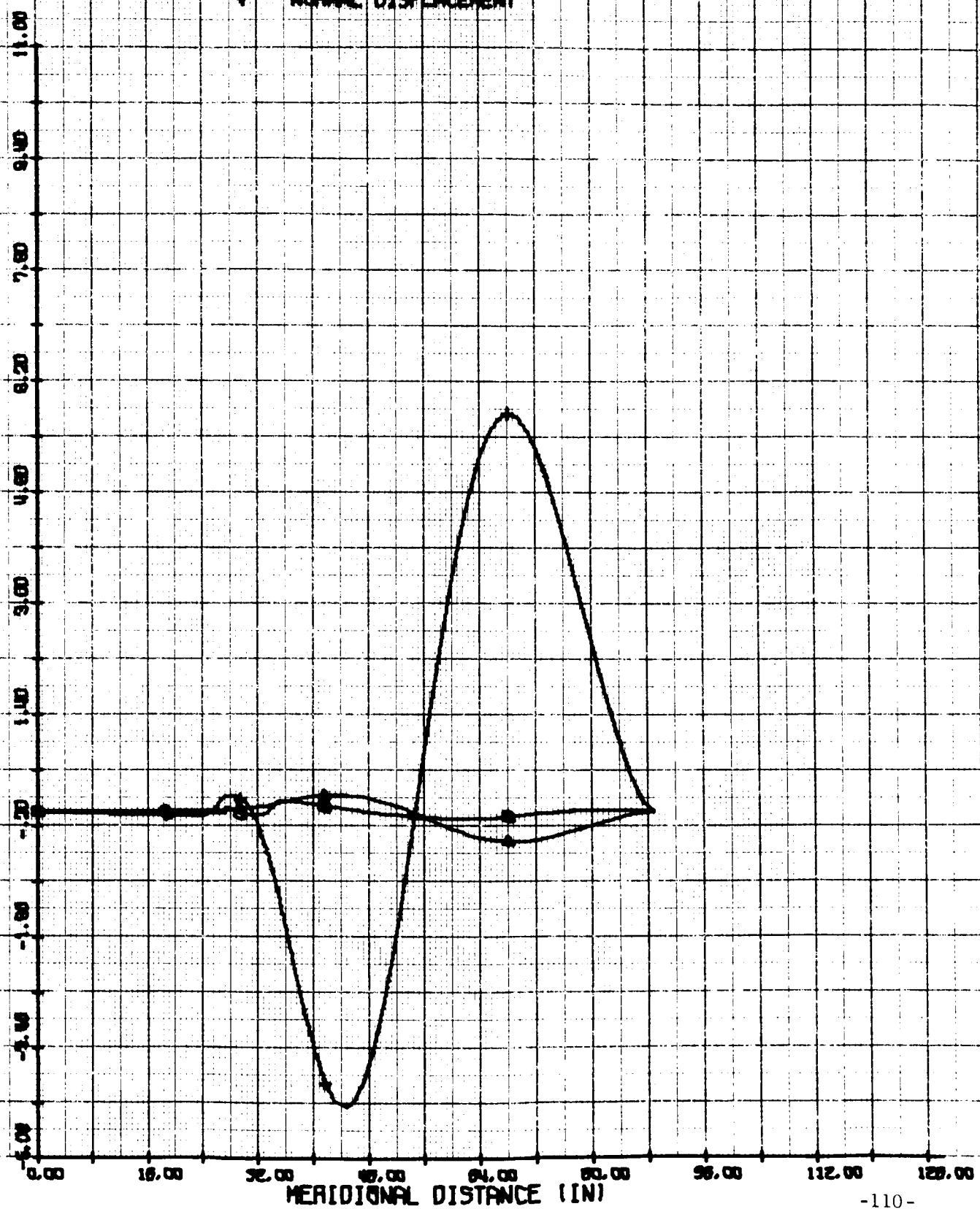


FIGURE 34C

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE 1 (165 IN BASE), OMEGA 3 = 148.0 CPS (IN/S)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

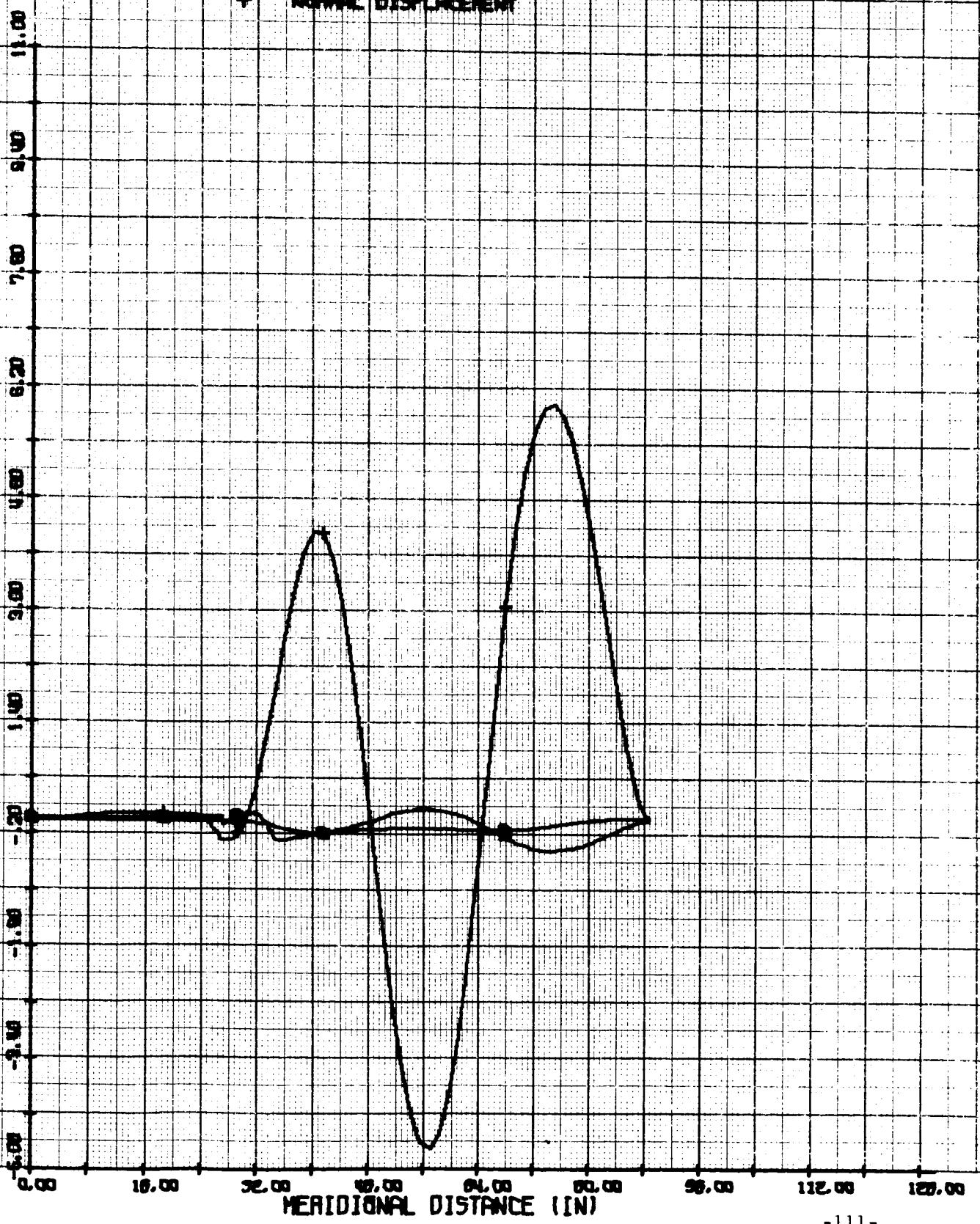


FIGURE 35a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (165 IN BASE). OMEGA 1 = 65.00 CPS [IN=7]

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

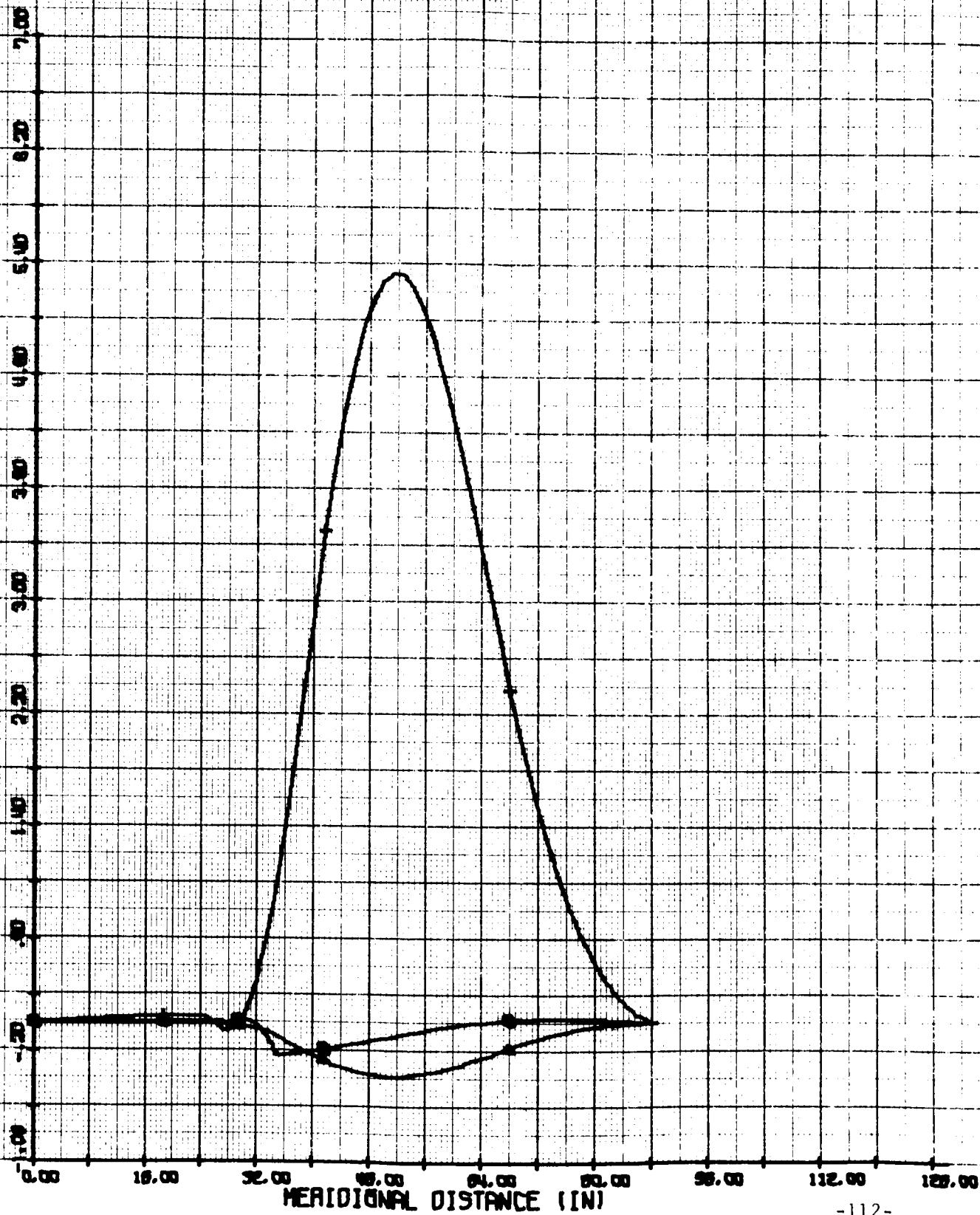


FIGURE 35b

VIBRATION MODE DISPLACEMENTS

NASA TRSK 3. CASE 1 (165 IN BASE). OMEGA Z = 112.5 CPS (N=7)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + RADIAL DISPLACEMENT

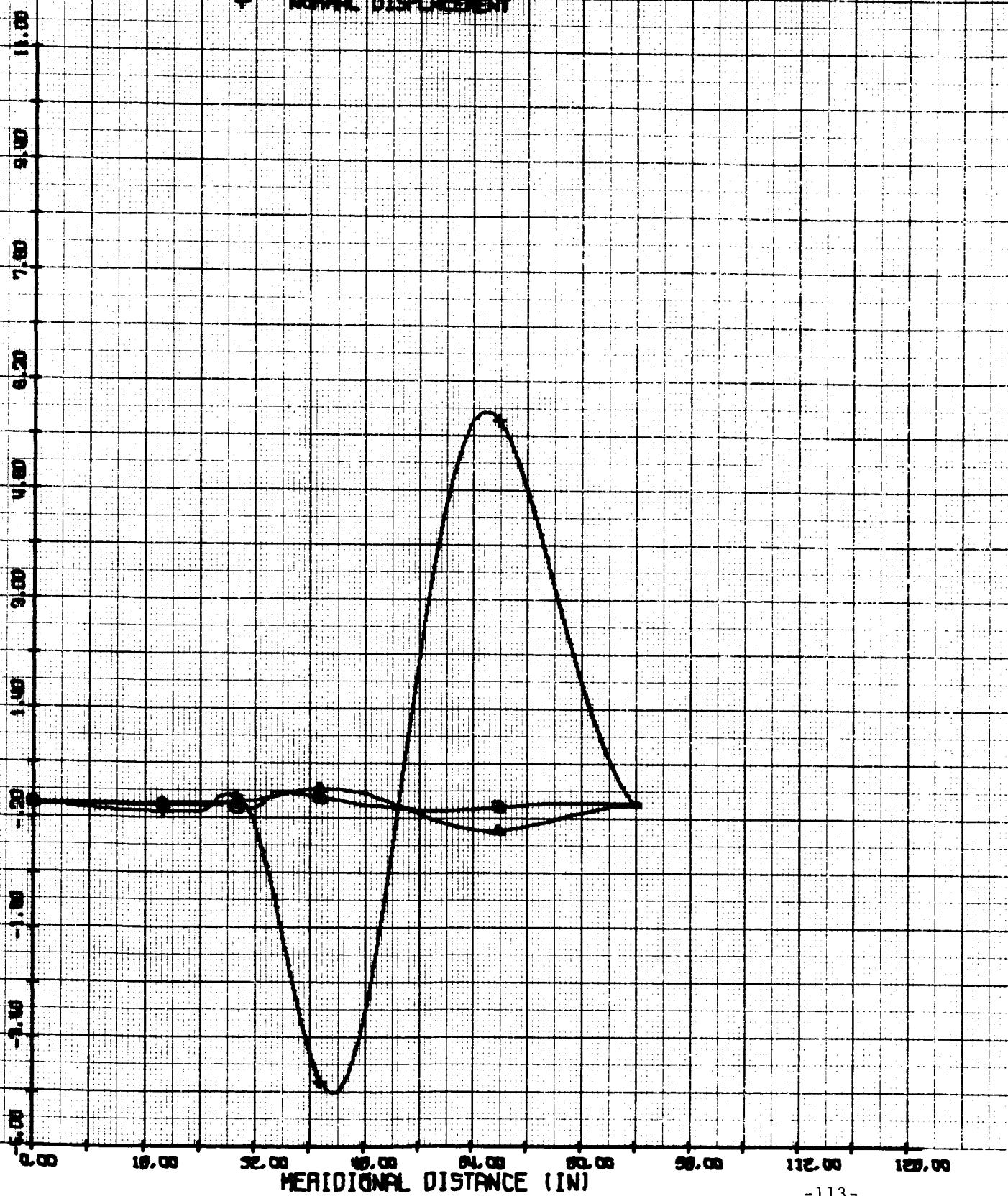


FIGURE 35c

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE 1 (165 IN BASE). OMEGA 3 = 165.3 CPS (N=7)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + RADIAL DISPLACEMENT

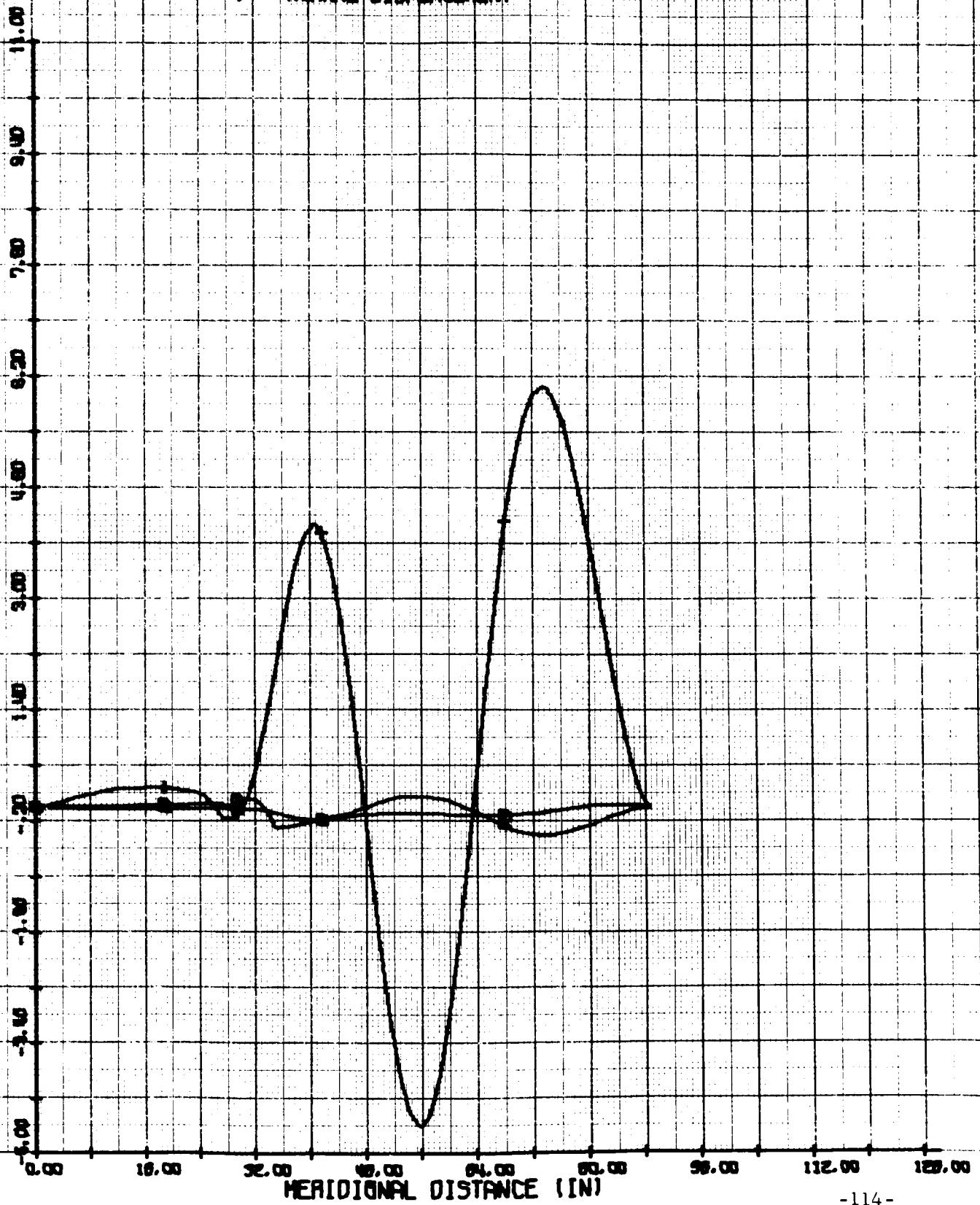


FIGURE 36a

VIBRATION MODE DISPLACEMENTS

NASA TRSM 3. CASE 1 (1165 IN BASE). OMEGA 1 = 78.30 (PS (N=8))

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

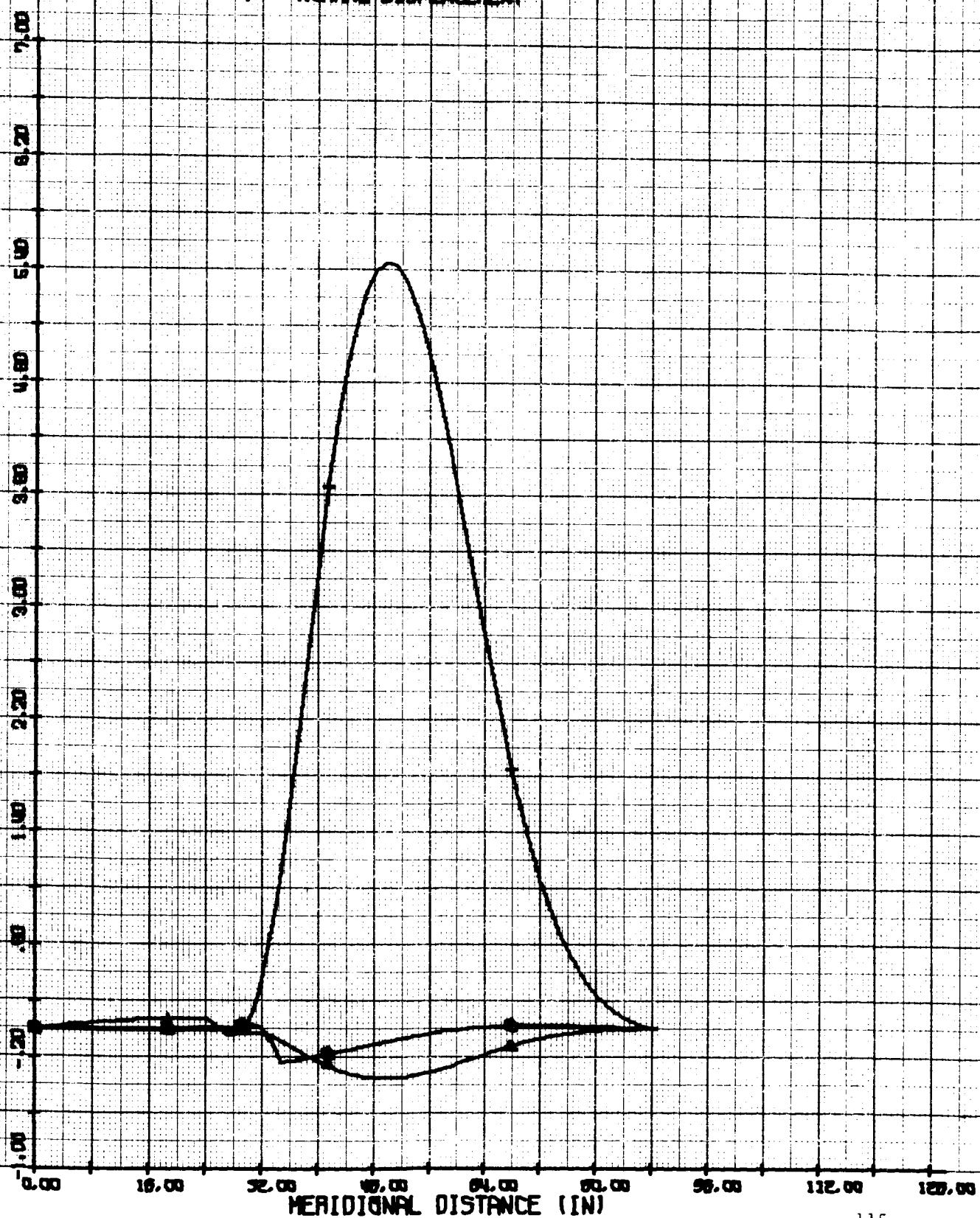


FIGURE 36b

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (165 IN BASE). OMEGA 2 = 129.8 CPS (N=8)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

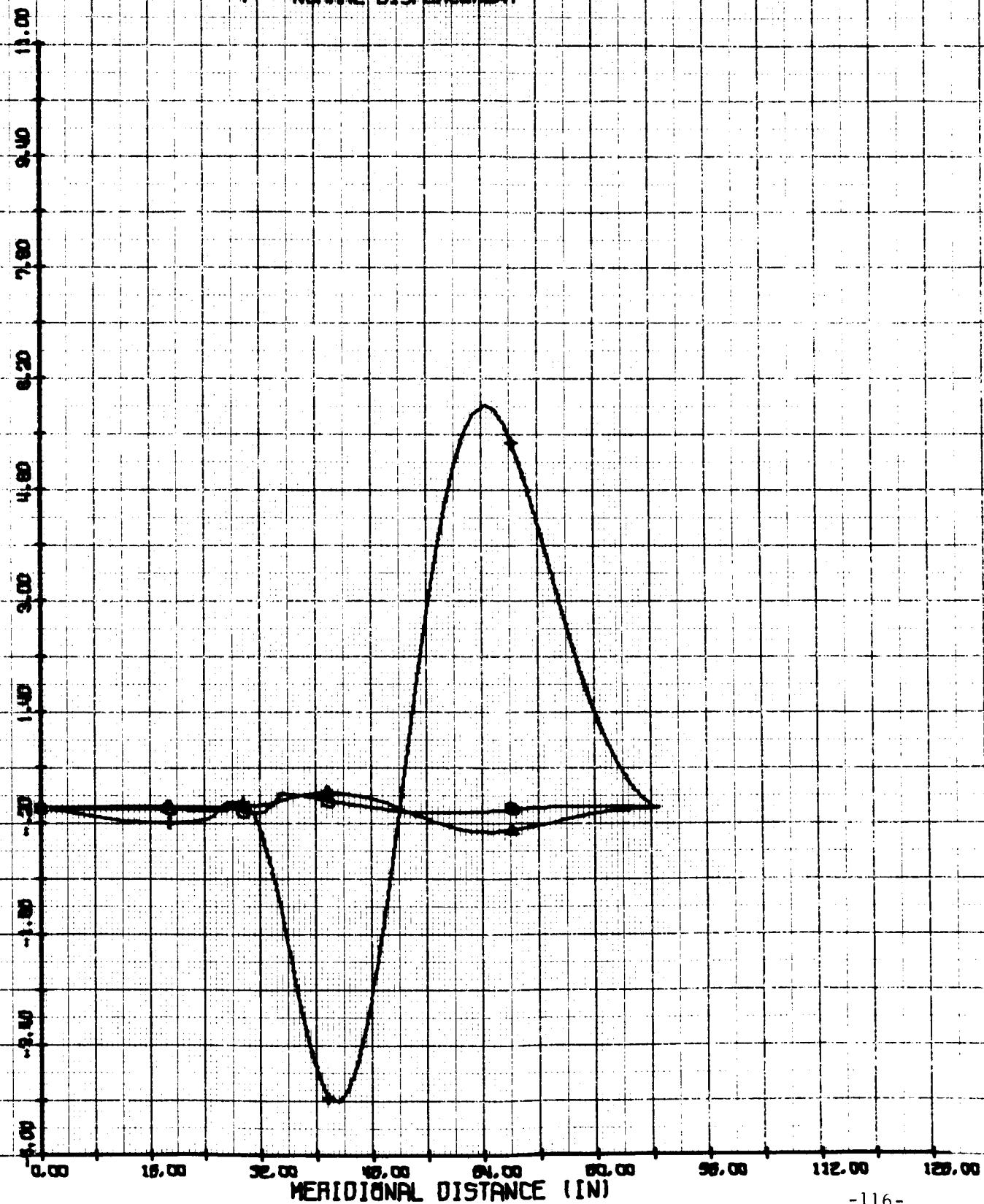


FIGURE 36c

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (165 IN BASE). OMEGA 3 = 185.6 CPS (N=8)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

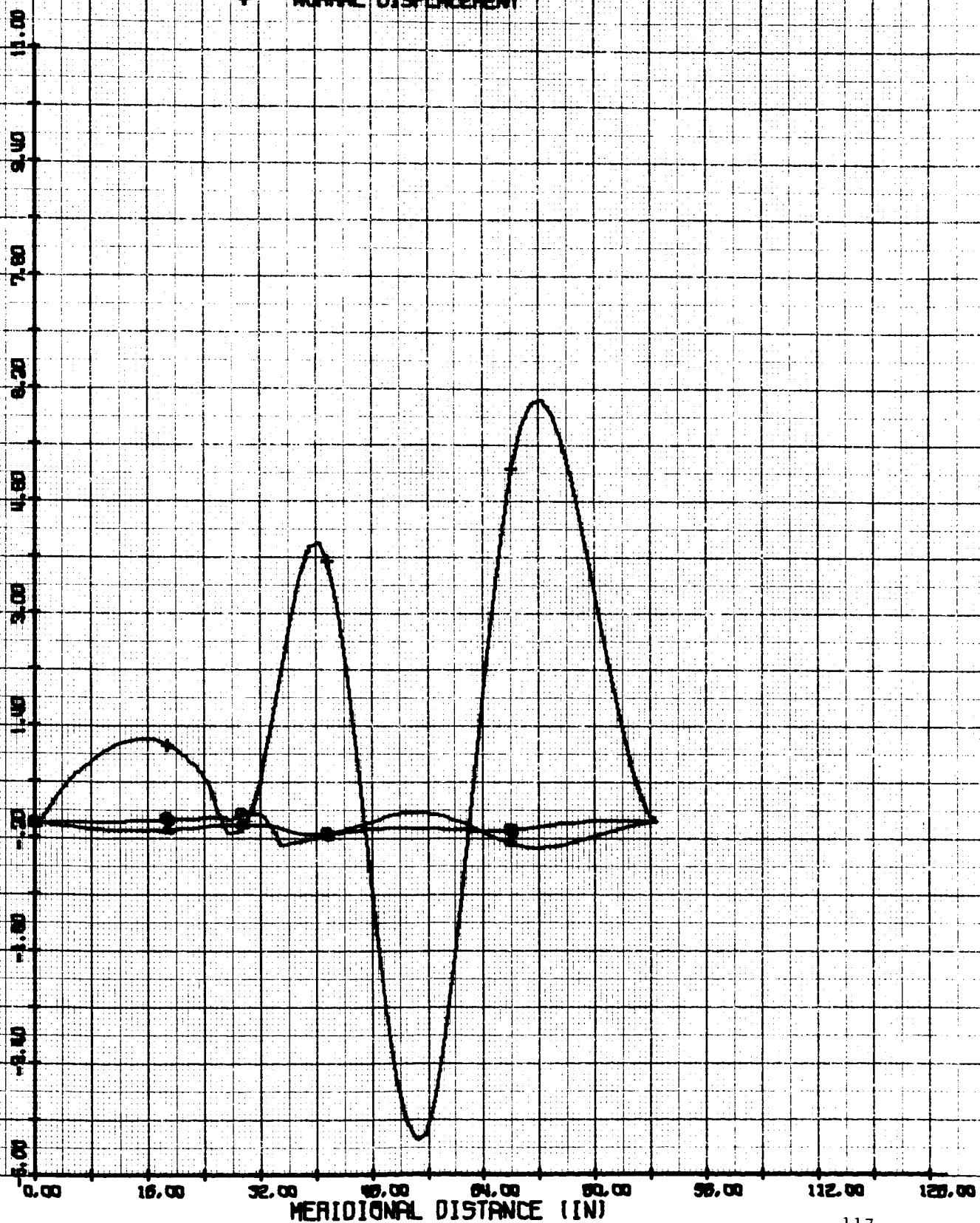


FIGURE 37a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (165 IN BASE). $\Omega = 92.95$ CPS (N=9)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

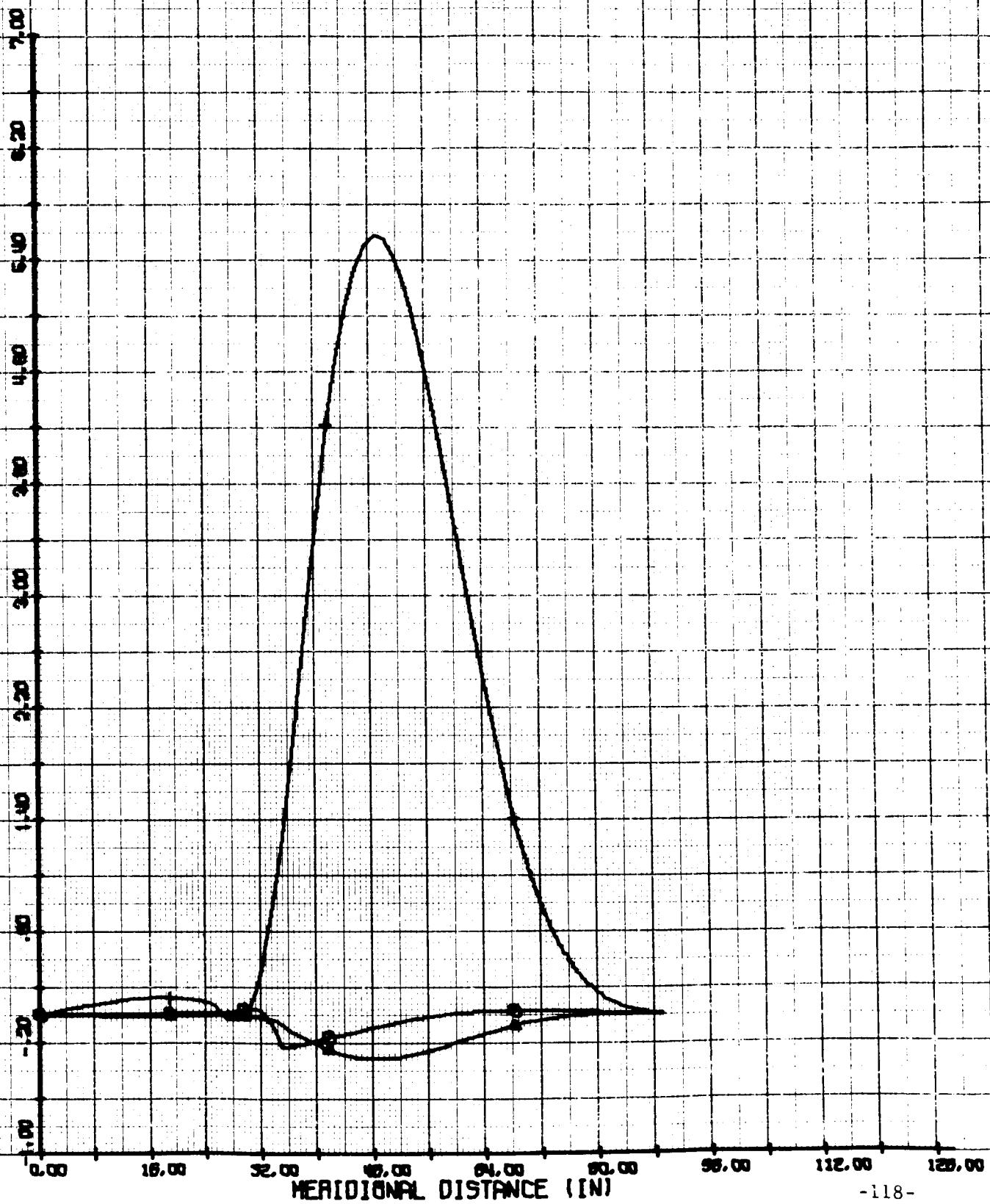


FIGURE 37b

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (165 IN BASE). OMEGA 2 = 148.9 CPS (N=9)

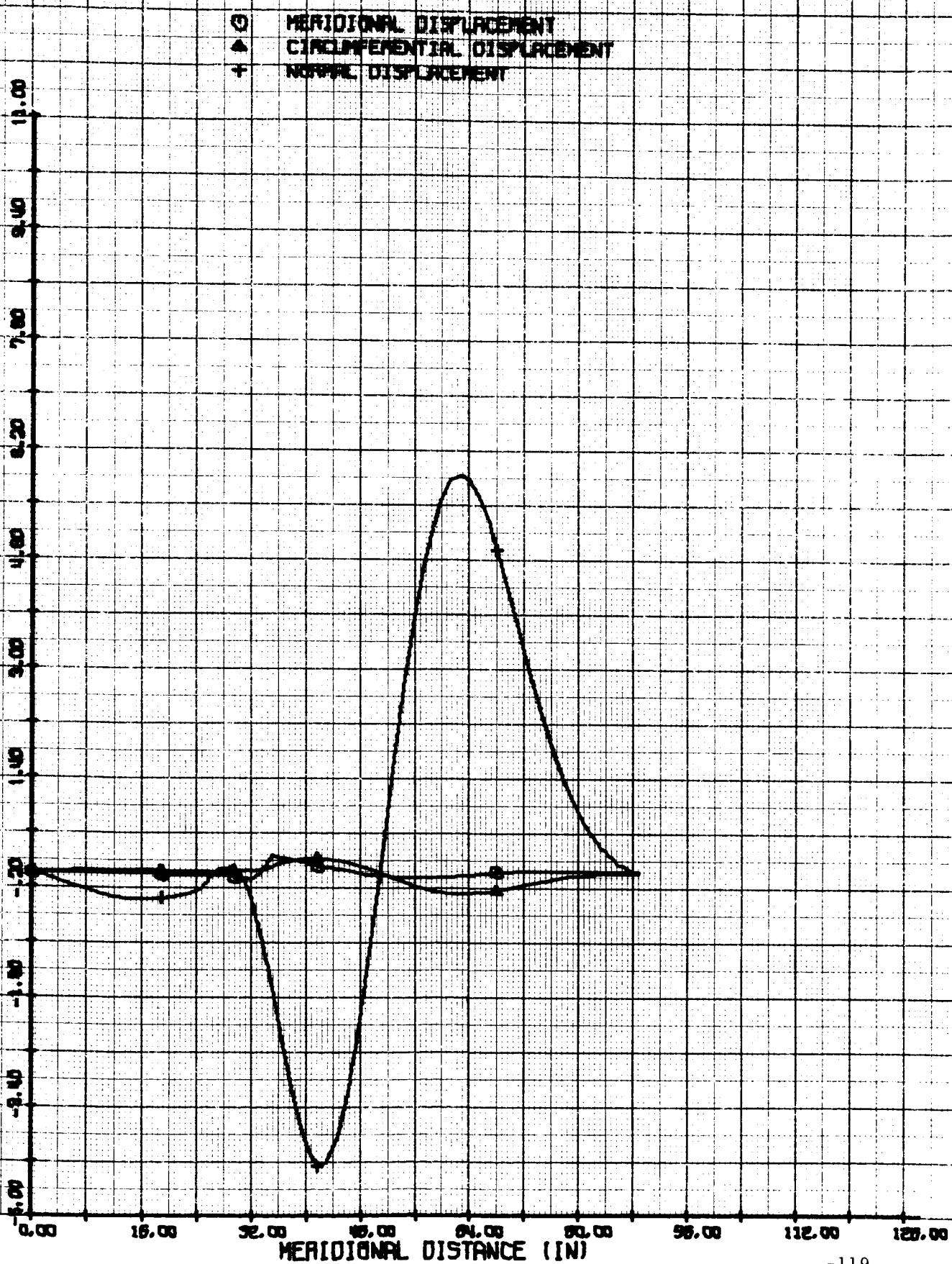


FIGURE 37c

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (165 IN BASE). (OMEGA 3 = 187.2 CPS (N=9)

- MERIDIONAL DISPLACEMENT
- △ CIRCUMFERENTIAL DISPLACEMENT
- + RADIAL DISPLACEMENT

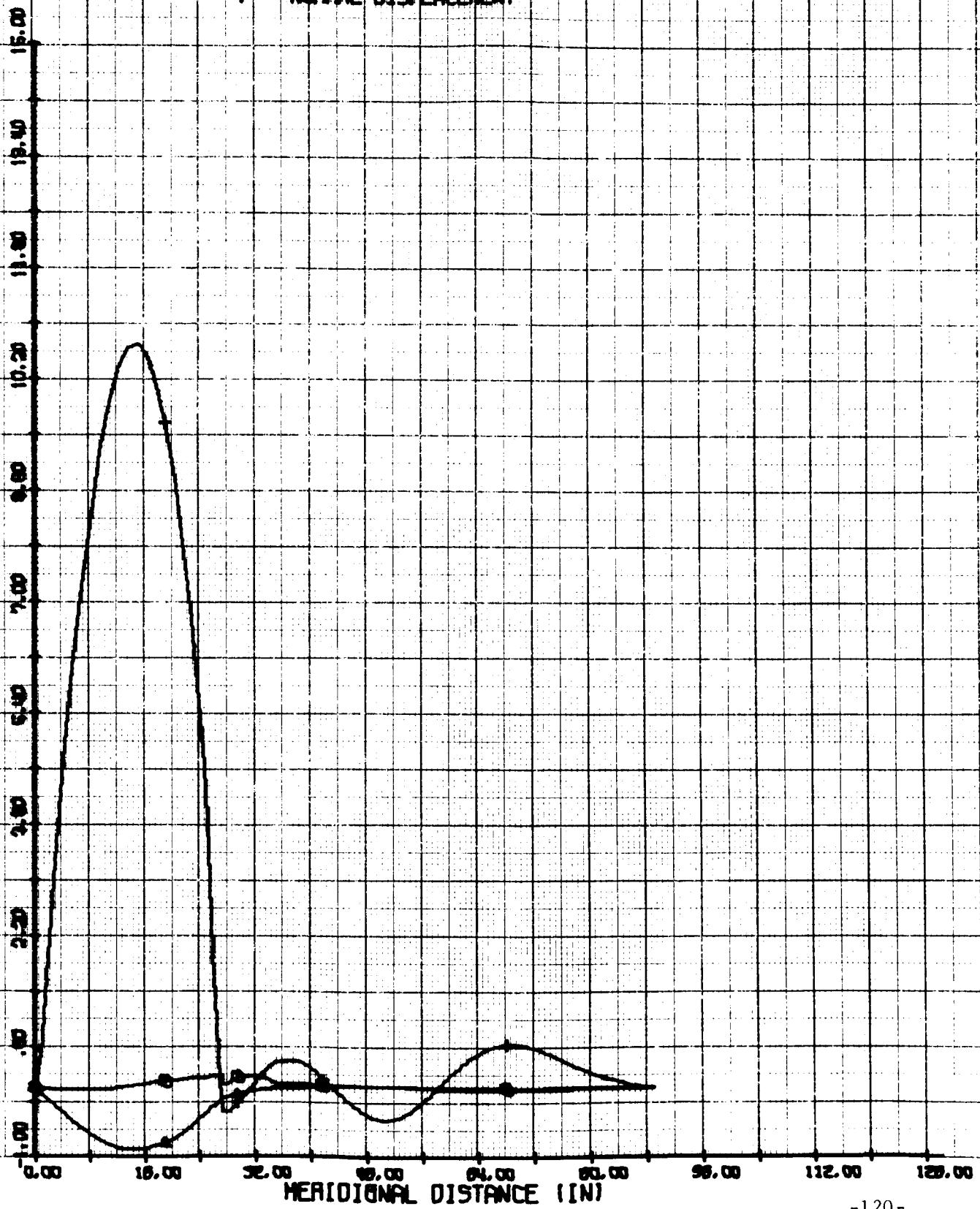


FIGURE 38a

VIBRATION MODE DISPLACEMENTS

NRSA TASK 3. CASE 1 (165 IN BASE) OMEGA 1 = 108.8 CPS (N=10)

- (○) MERIDIONAL DISPLACEMENT
- (▲) CIRCUMFERENTIAL DISPLACEMENT
- (+) NORMAL DISPLACEMENT

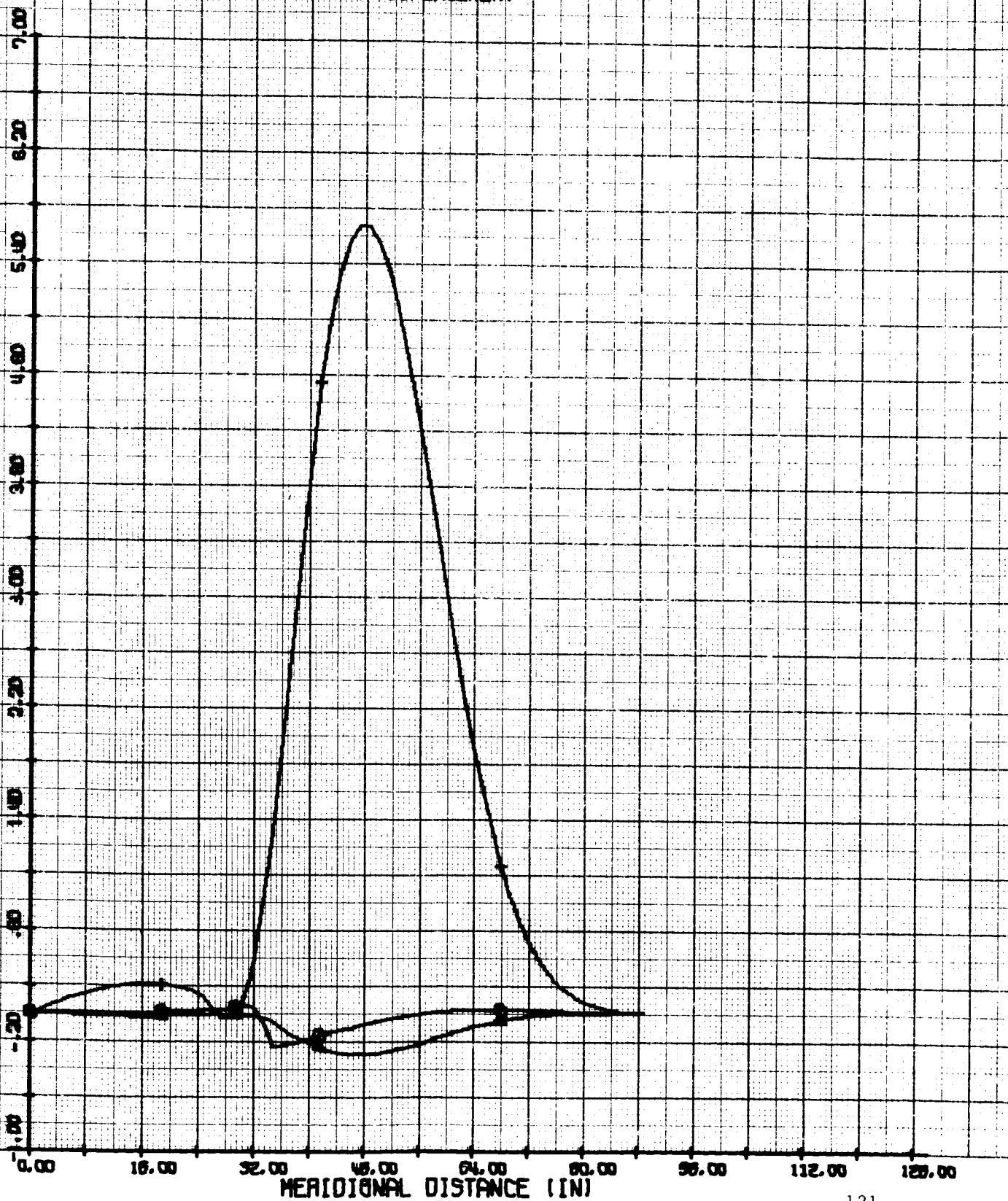


FIGURE 385

VIBRATION MODE DISPLACEMENTS

NRSR TASK 3. CASE I (165 IN BASE) OMEGA 2 = 168.4 CPS (N=10)

- MERIDIONAL DISPLACEMENT
- △ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

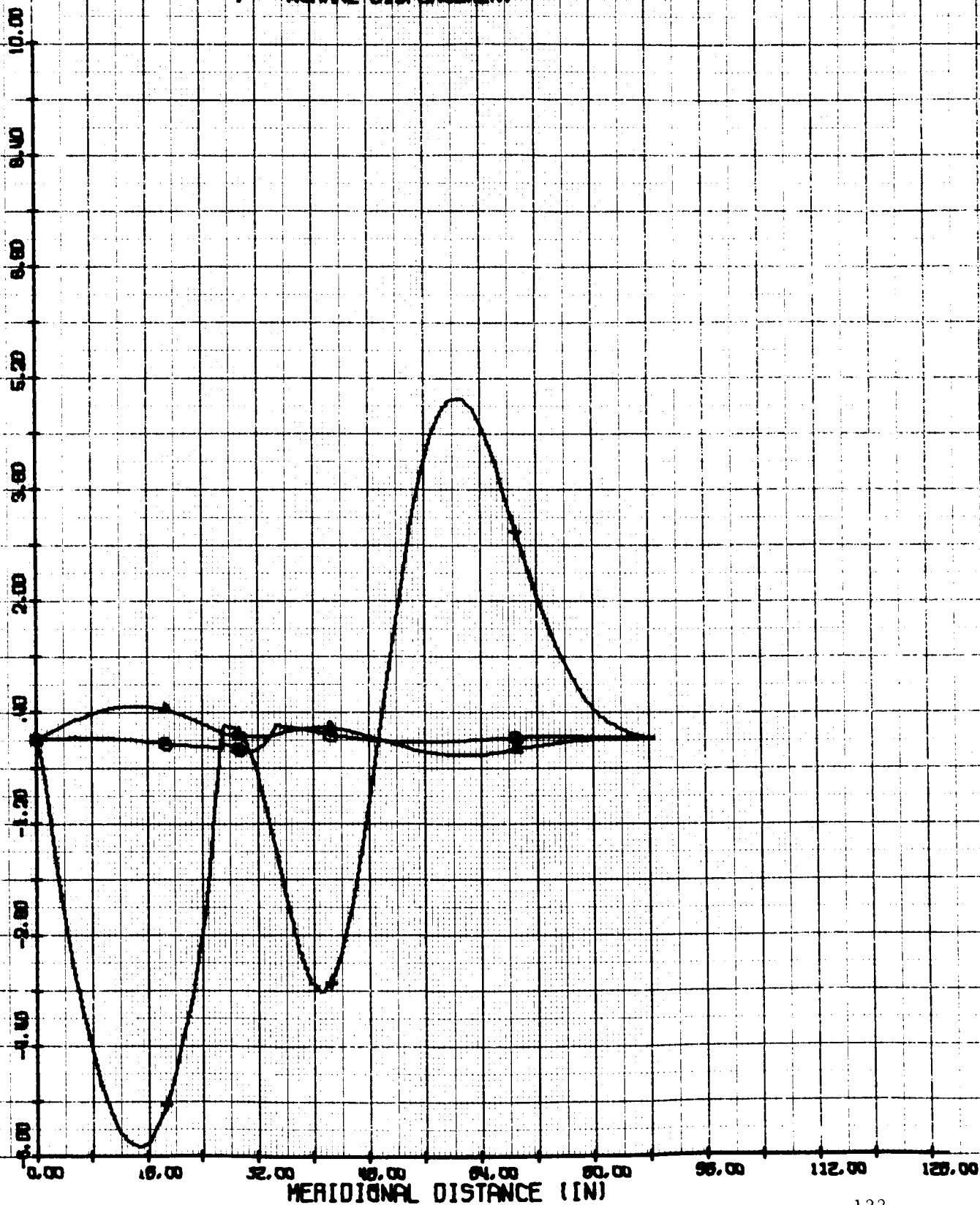


FIGURE 38c

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE I (165 IN BASE) OMEGA 3 = 172.3 CPS (N=10)

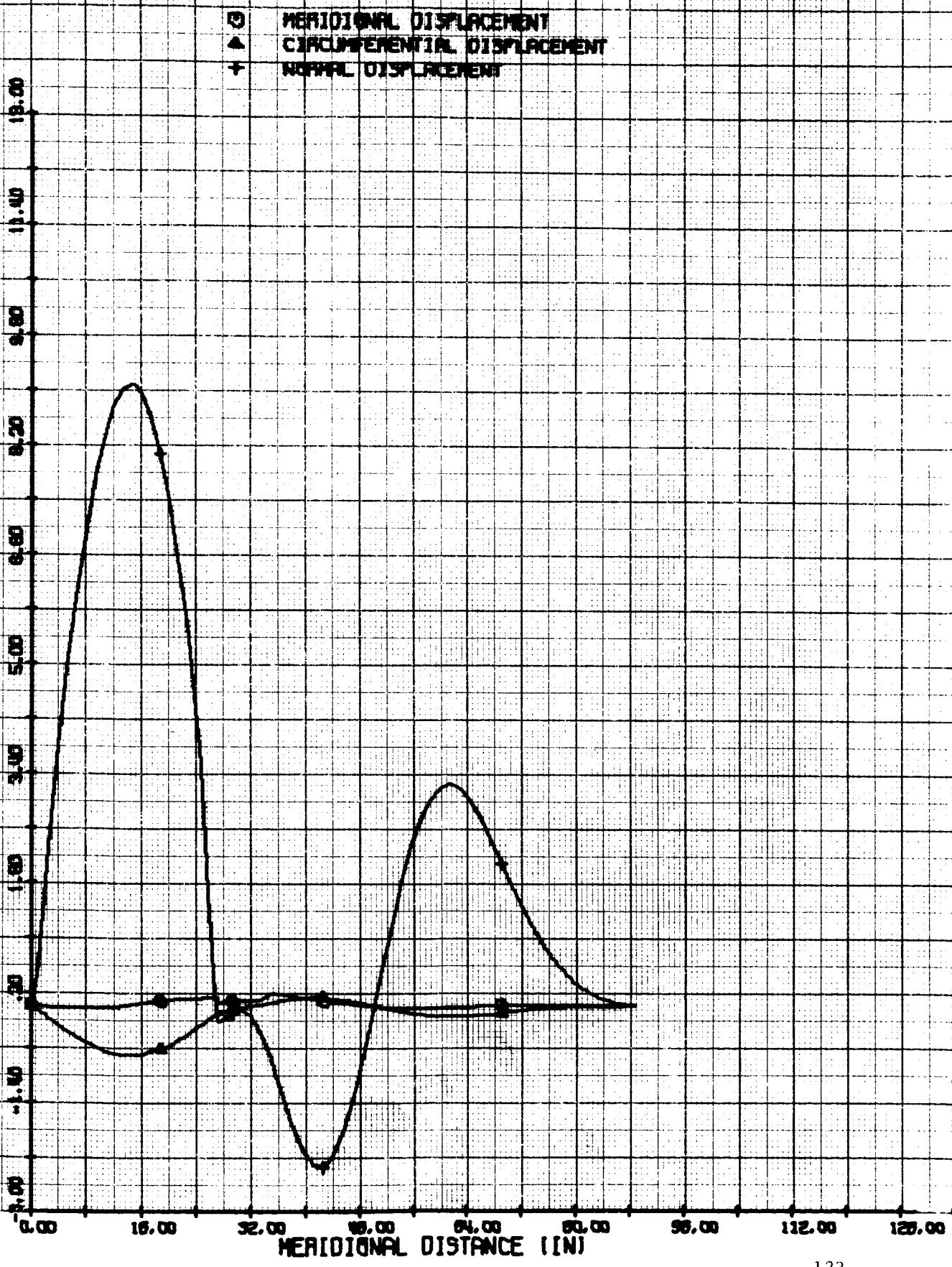


FIGURE 39a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE II (120 IN BASE) OMEGA 1 = 39.03 CPS (N=0)

- (○) MERIDIONAL DISPLACEMENT
- (▲) CIRCUMFERENTIAL DISPLACEMENT
- (+) NORMAL DISPLACEMENT

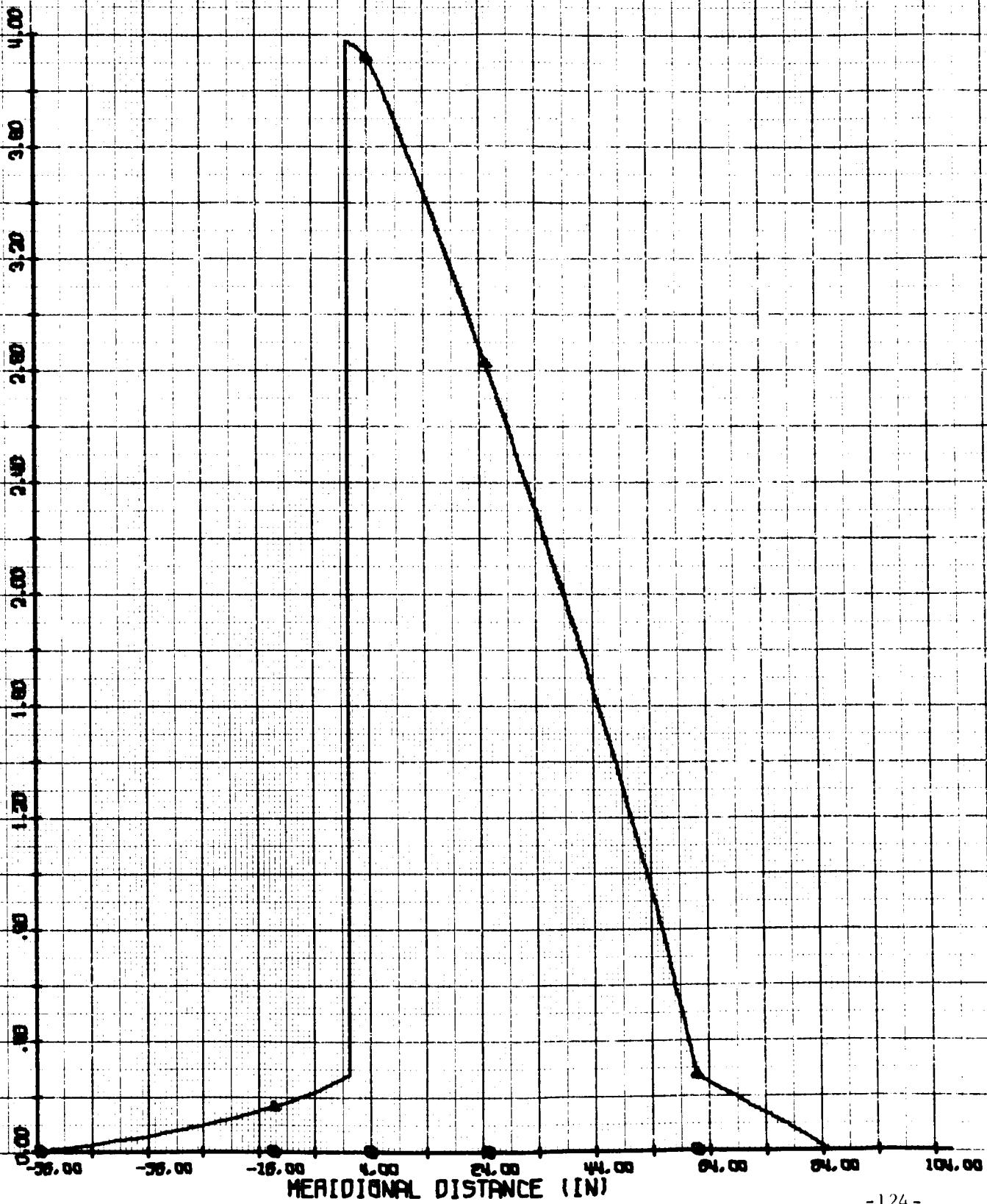


FIGURE 39b

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE II (120 IN BASE) OMEGA Z = 40.47 CPS (N=0)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

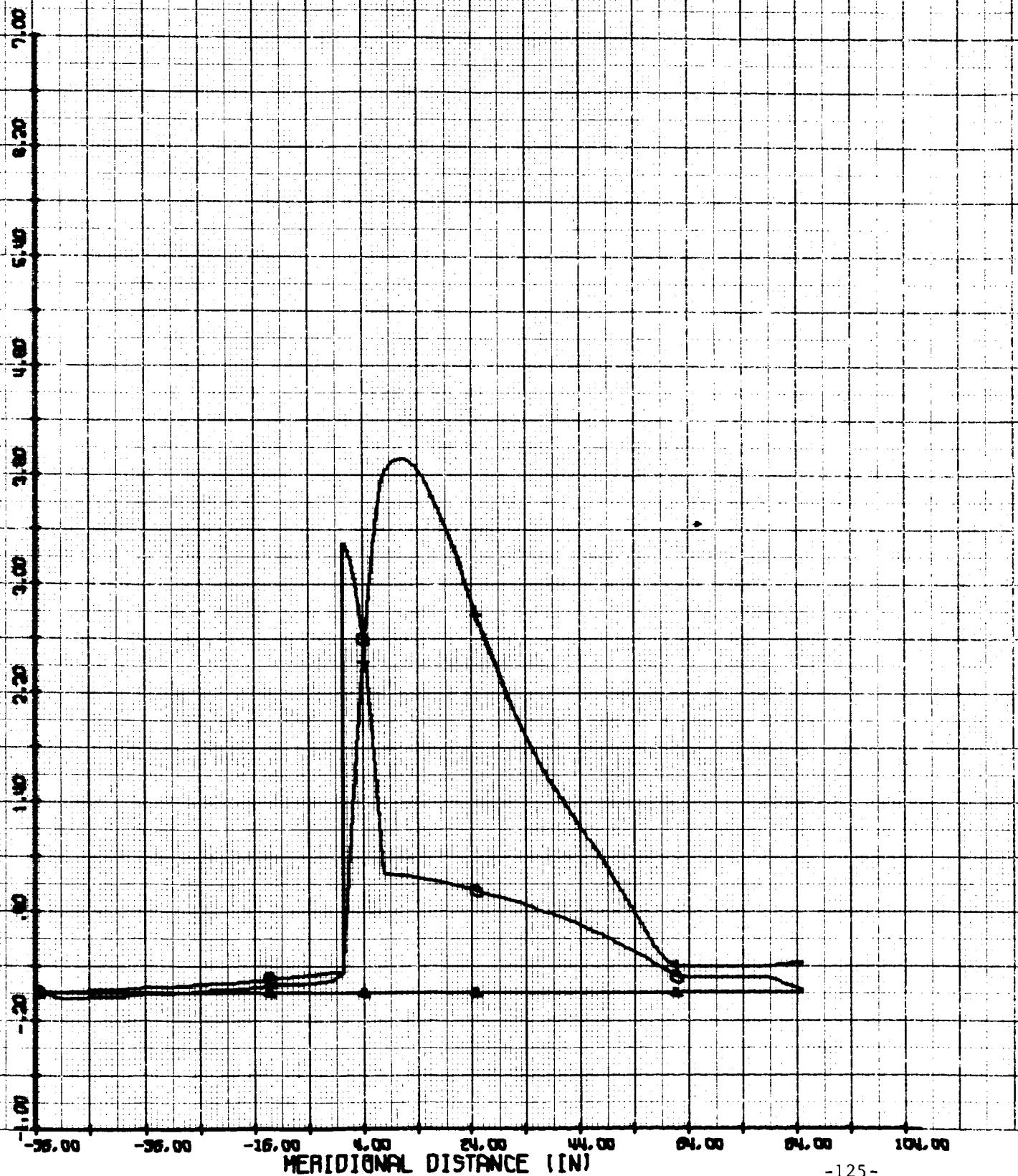


FIGURE 39C

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE II (120 IN BASE) OMEGA 3 = 70.64 CPS (N=0)

- ◎ MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

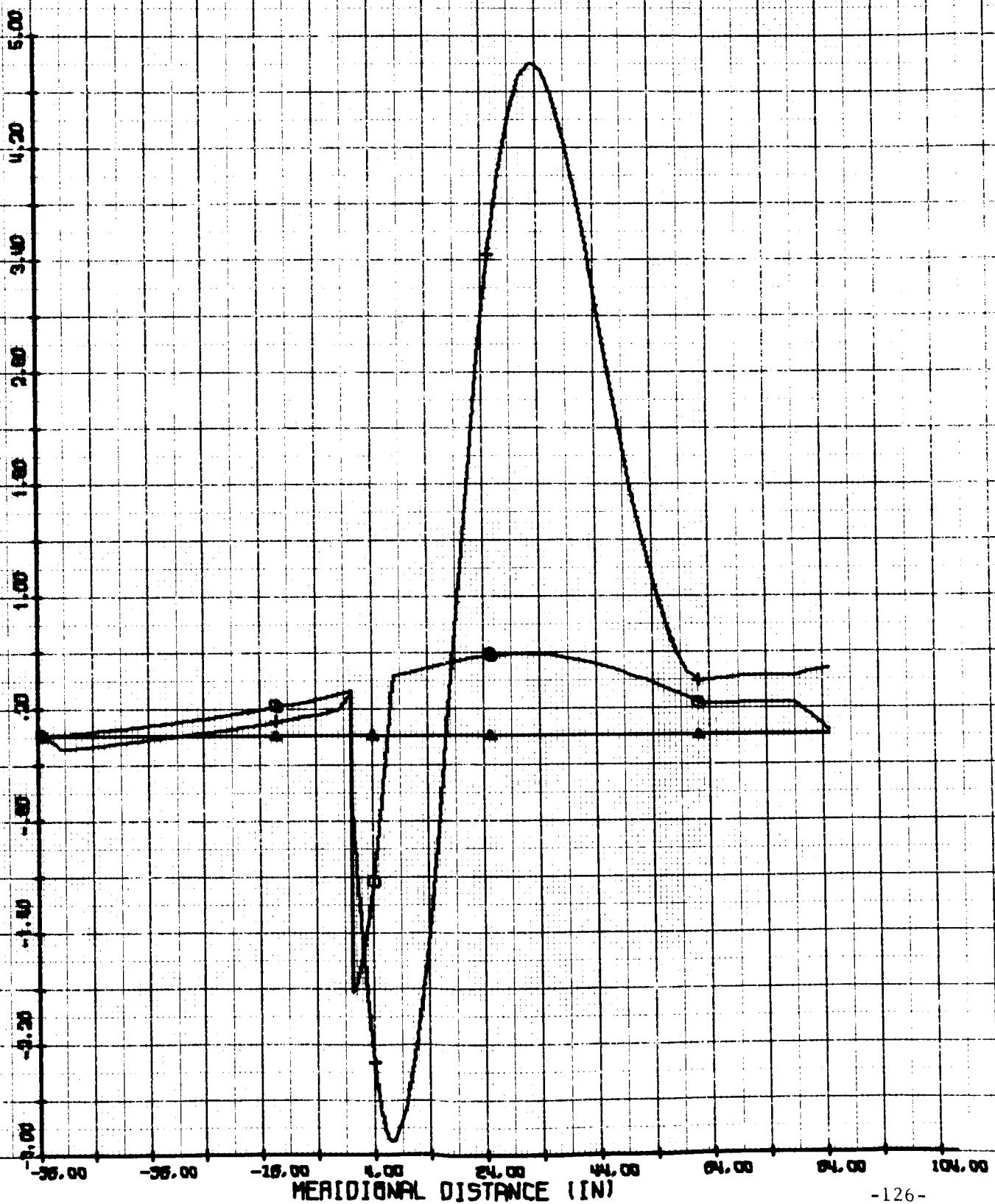


FIGURE 40a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE II (120 IN BASE) OMEGA 1 = 15.70 CPS (N=1)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

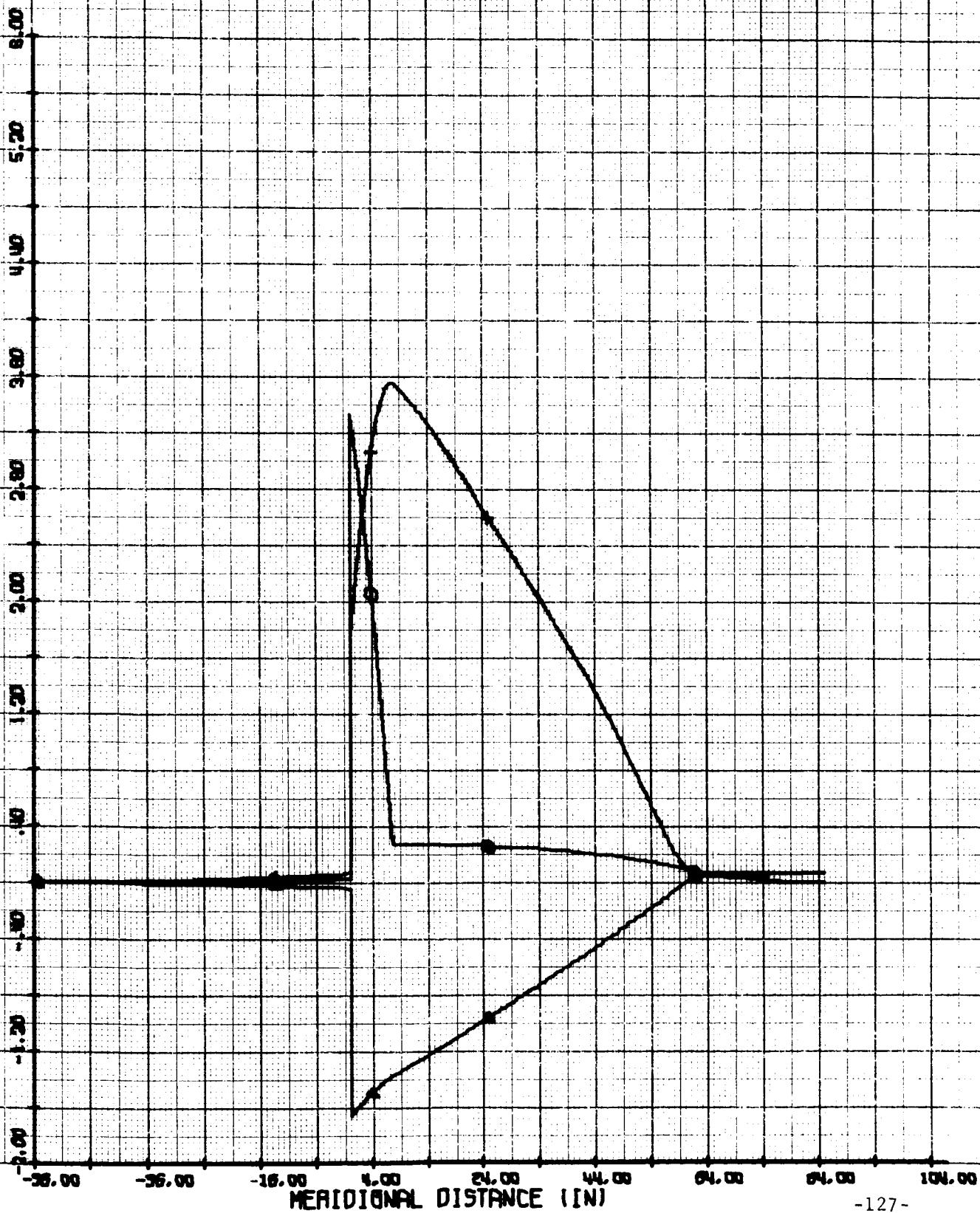


FIGURE 40B

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE II (120 IN BASE) OMEGA 2 = 59.19 CPS (IN=1)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

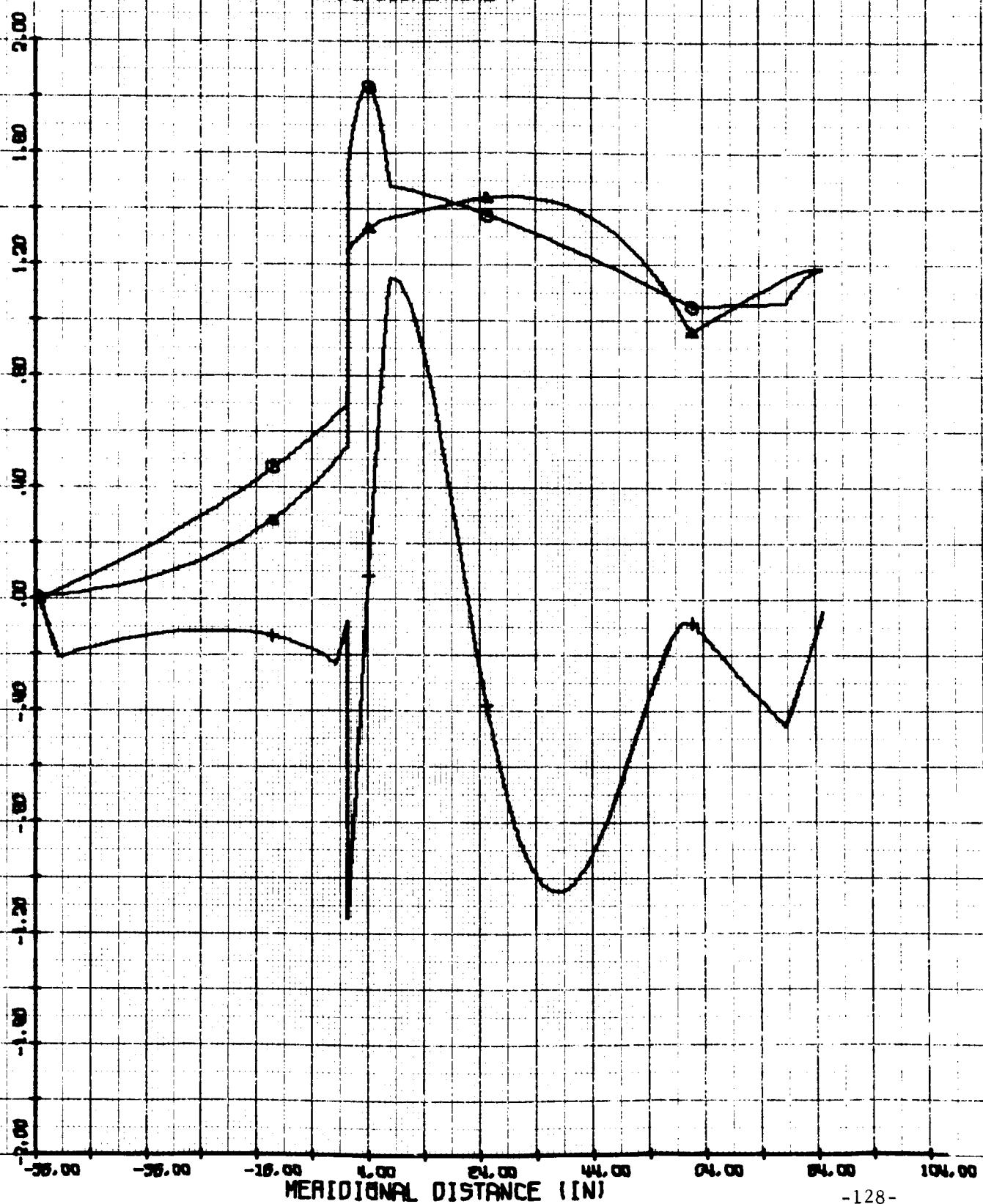


FIGURE 40c

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE II (120 IN ERSE) OMEGA 3 = 66.86 (PS [N=1])

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

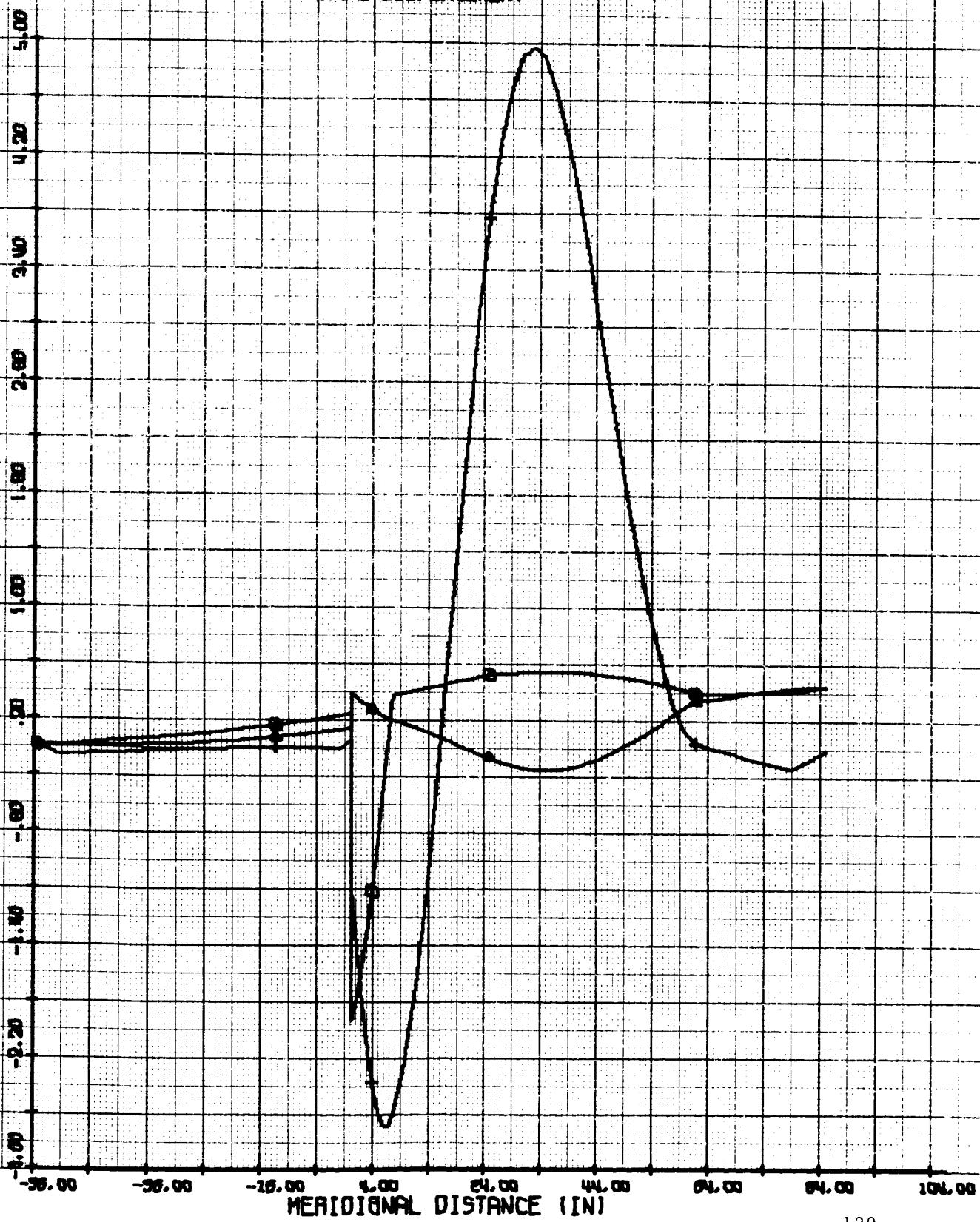


FIGURE 41a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE II (165 IN BASE) OMEGA 1 = 38.57 CPS (IN=0)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

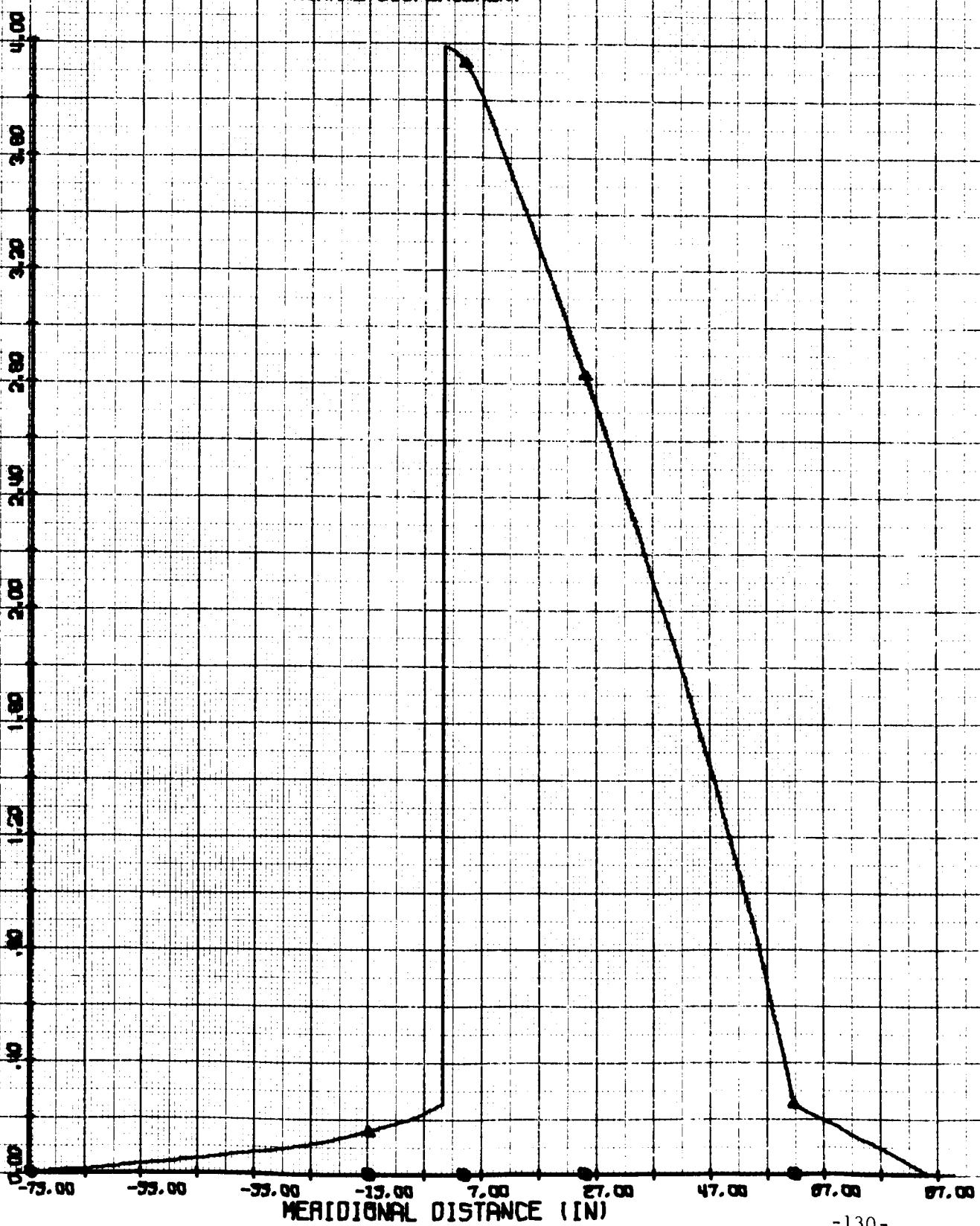


FIGURE 41b

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE II (165 IN BASE) OMEGA 2 = 38.69 CPS (N=0)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

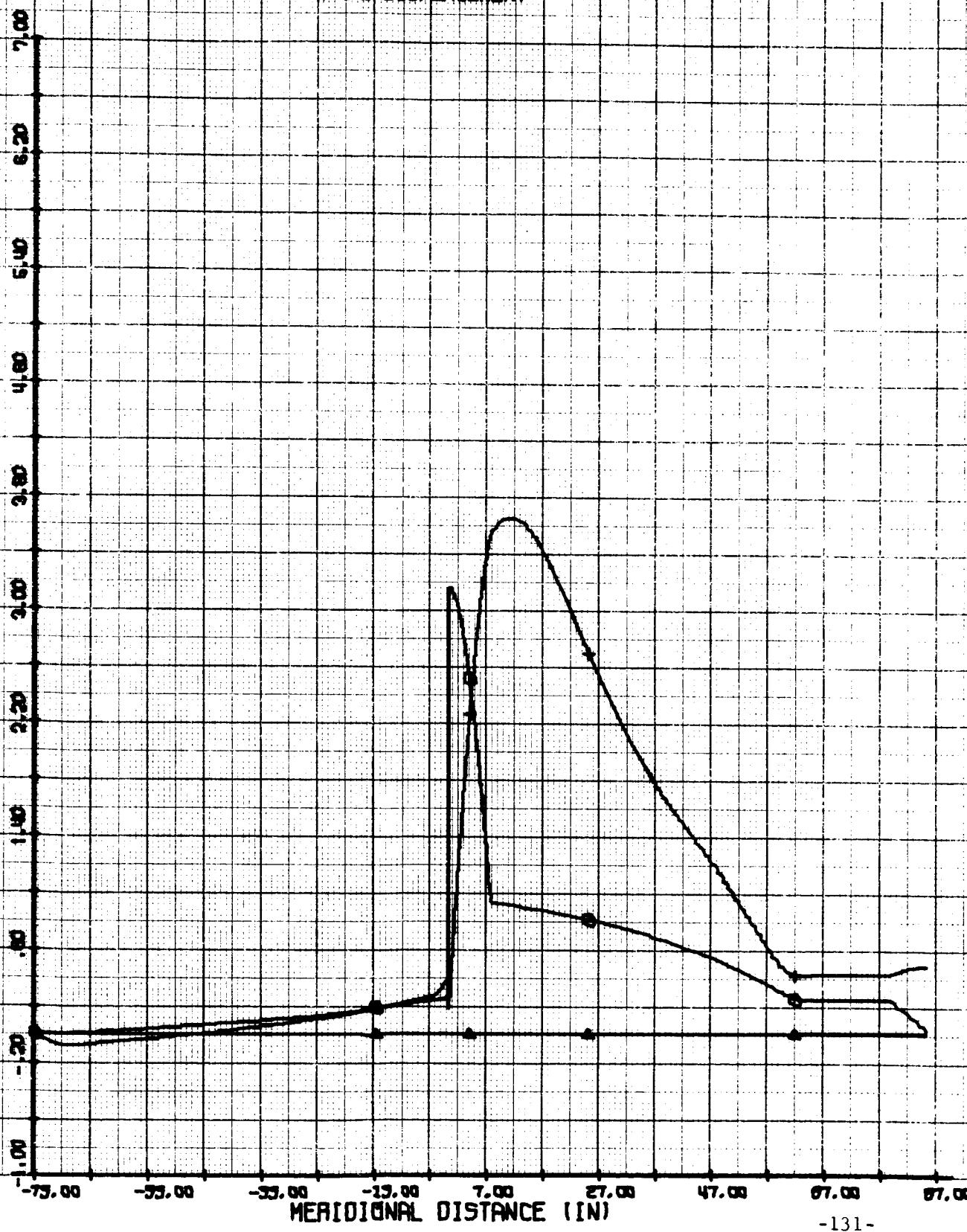


FIGURE 41c

VIBRATION MODE DISPLACEMENTS

NASA TASK 3. CASE II (165 IN BASE) OMEGA 3 = 62.40 CPS (N=0)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

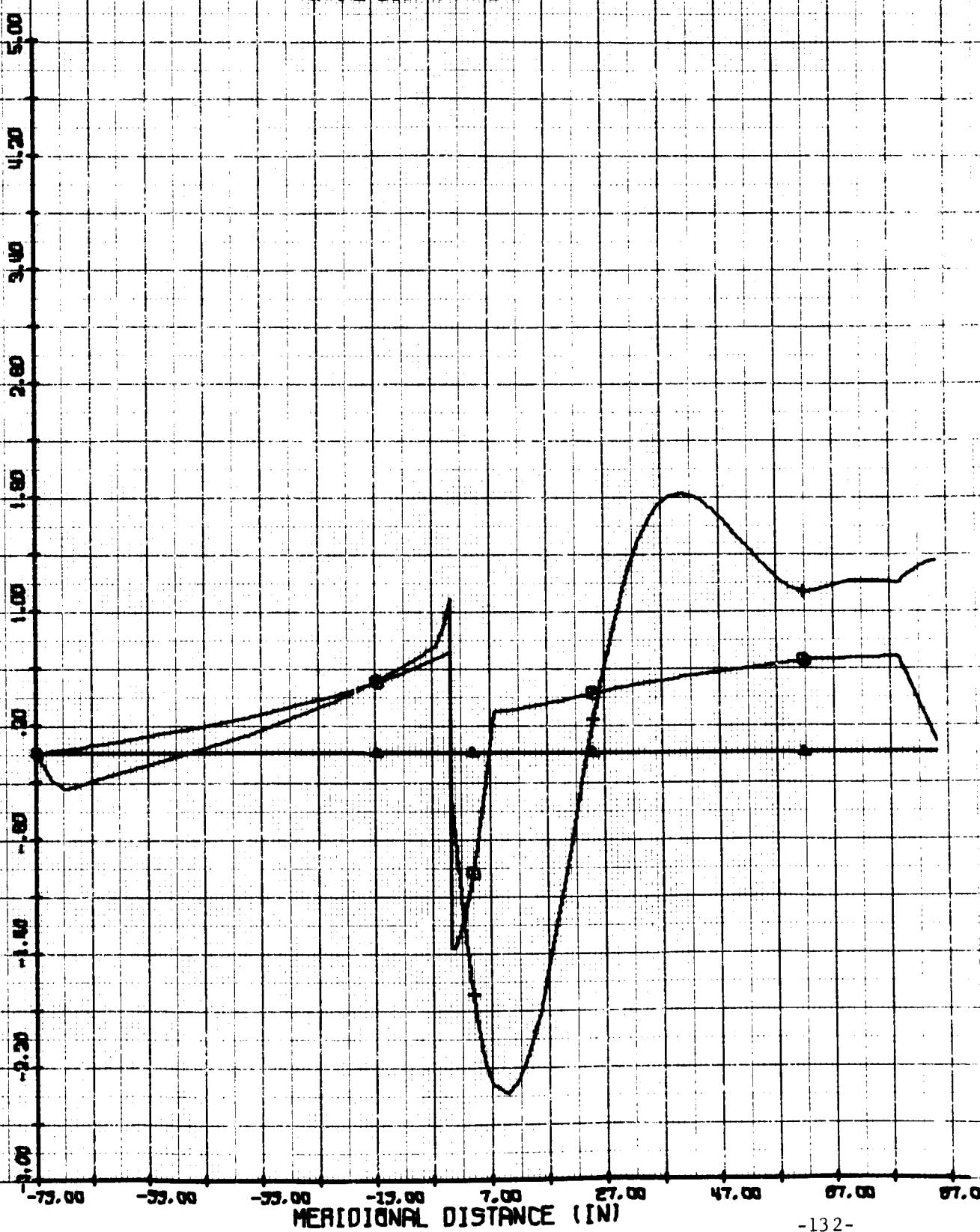


FIGURE 42a

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE II (165 IN BRSE) OMEGA 1 = 15.29 CPS (IN \pm 1)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

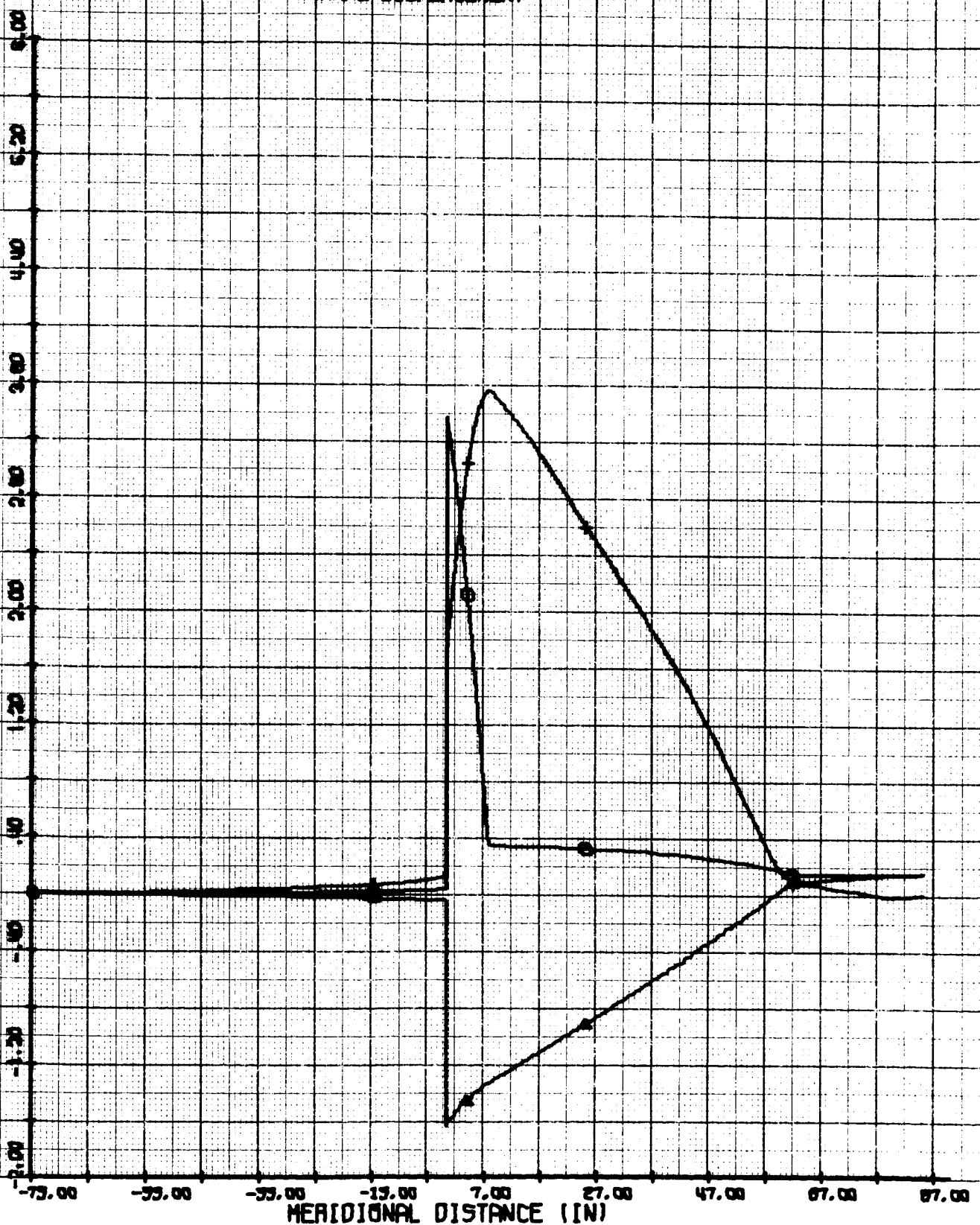


FIGURE 42b

VIBRATION MODE DISPLACEMENTS

NBSR TASK 3. CASE II (165 IN BASE) OMEGA 2 = 52.40 CPS (N=1)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

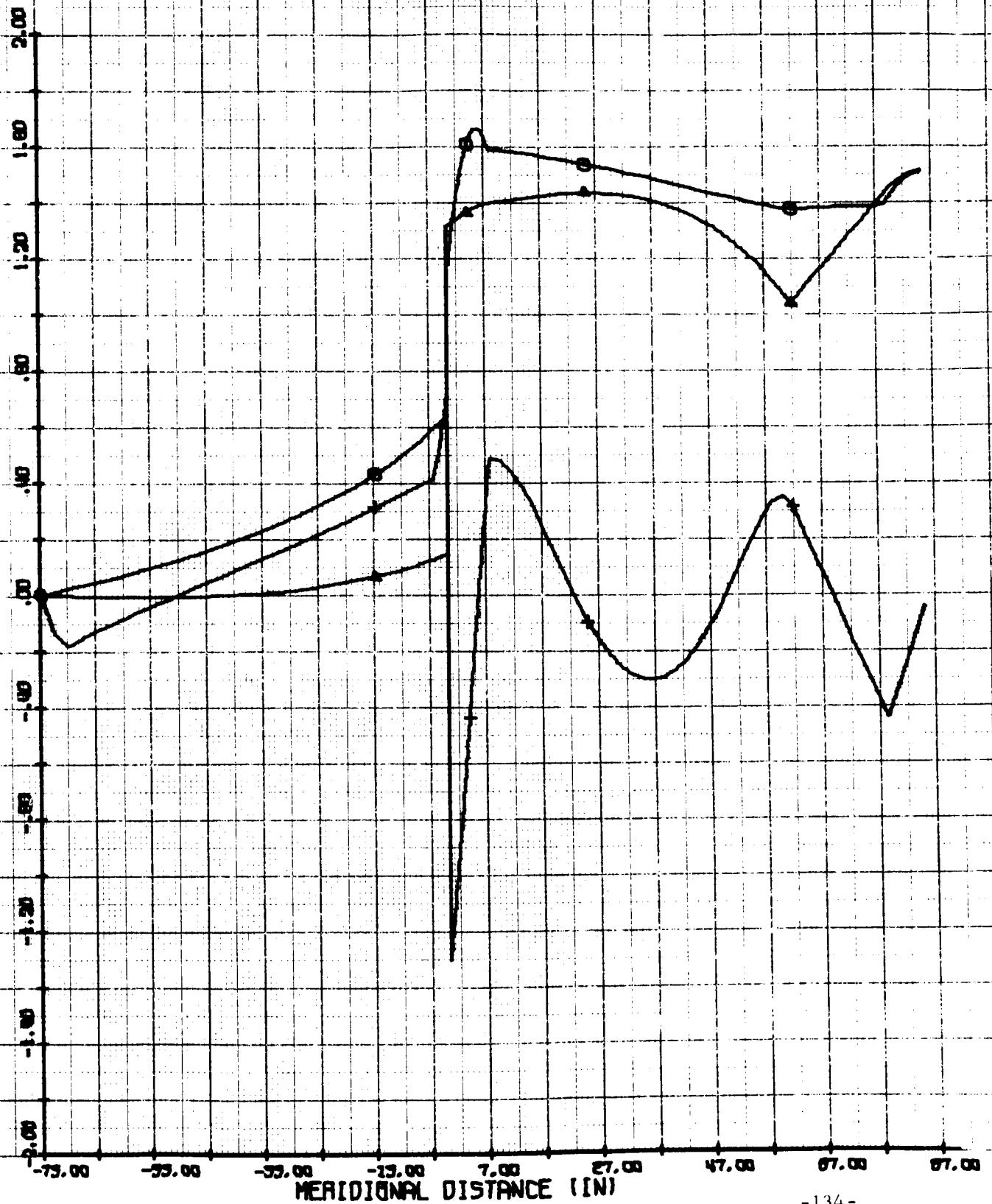


FIGURE 42c

VIBRATION MODE DISPLACEMENTS

NASA TASK 3, CASE II (165 IN BASE) OMGR 3 = 68.14 CPS (N=1)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

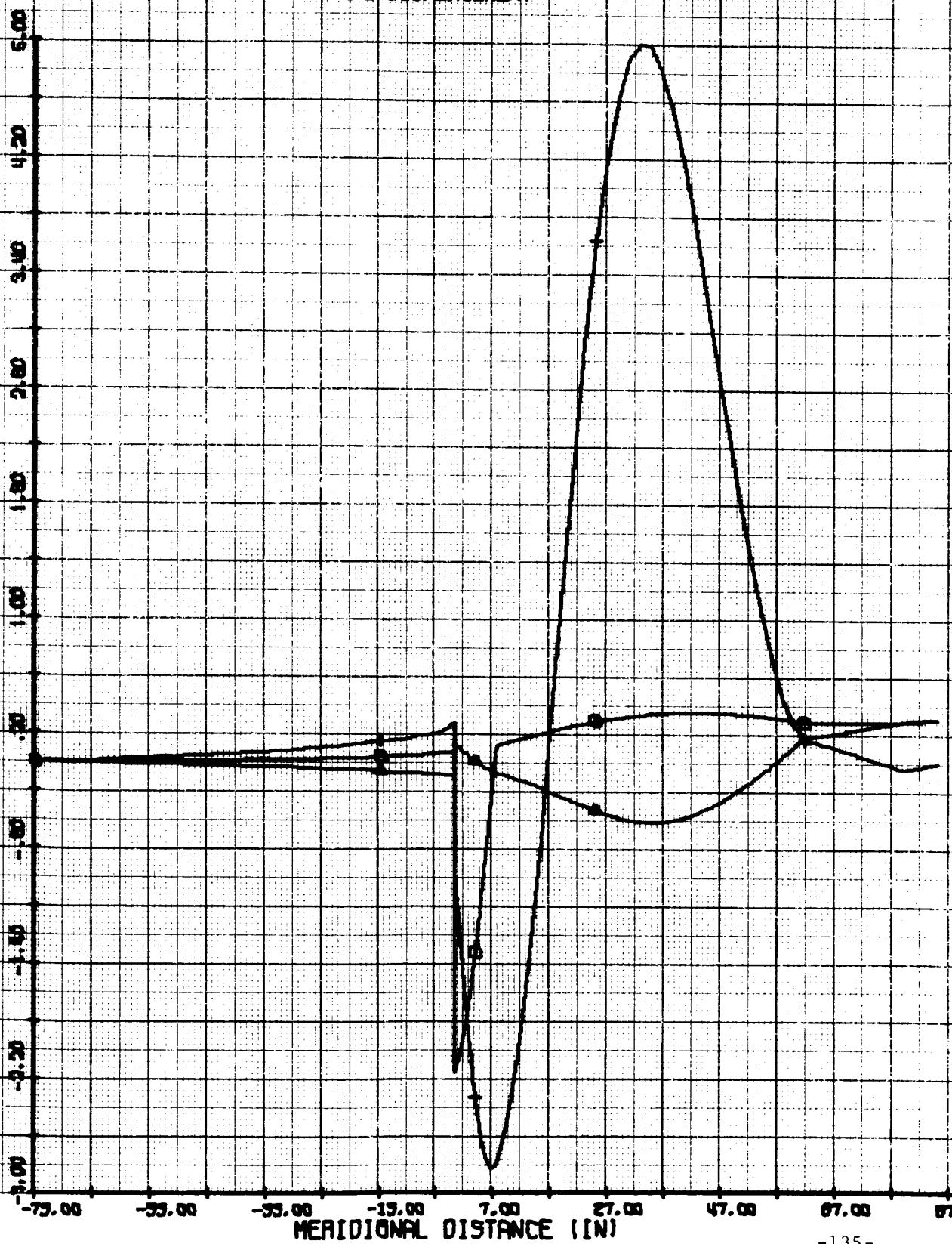


FIGURE 4Ba

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA 1=13.09 CPS (N=2)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

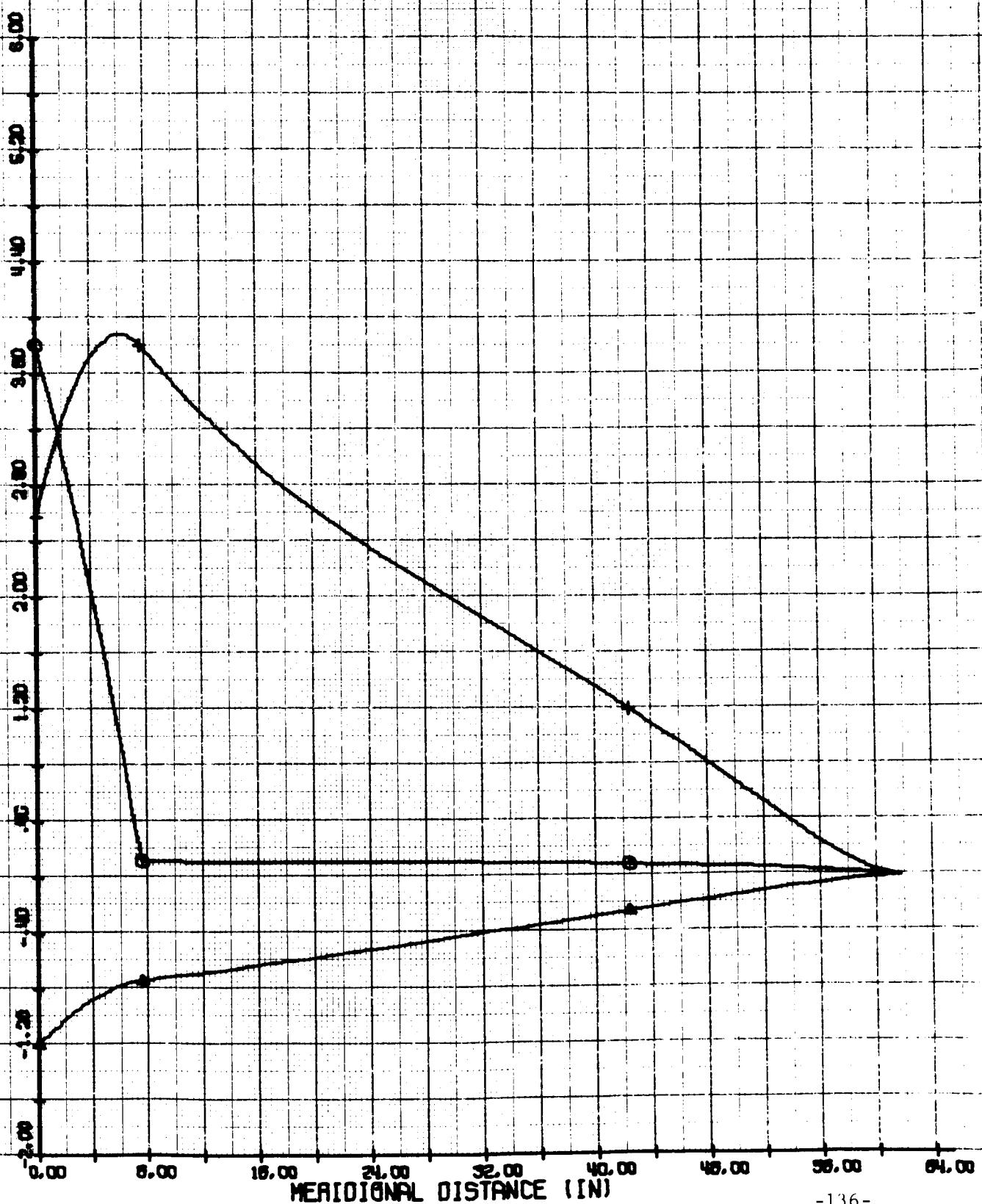


FIGURE 43b

VIBRATION MODE DISPLACEMENTS

CASE III. CAPSULE SHELL OVERHANG. OMEGA 2-53.00 CPS (N=2)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

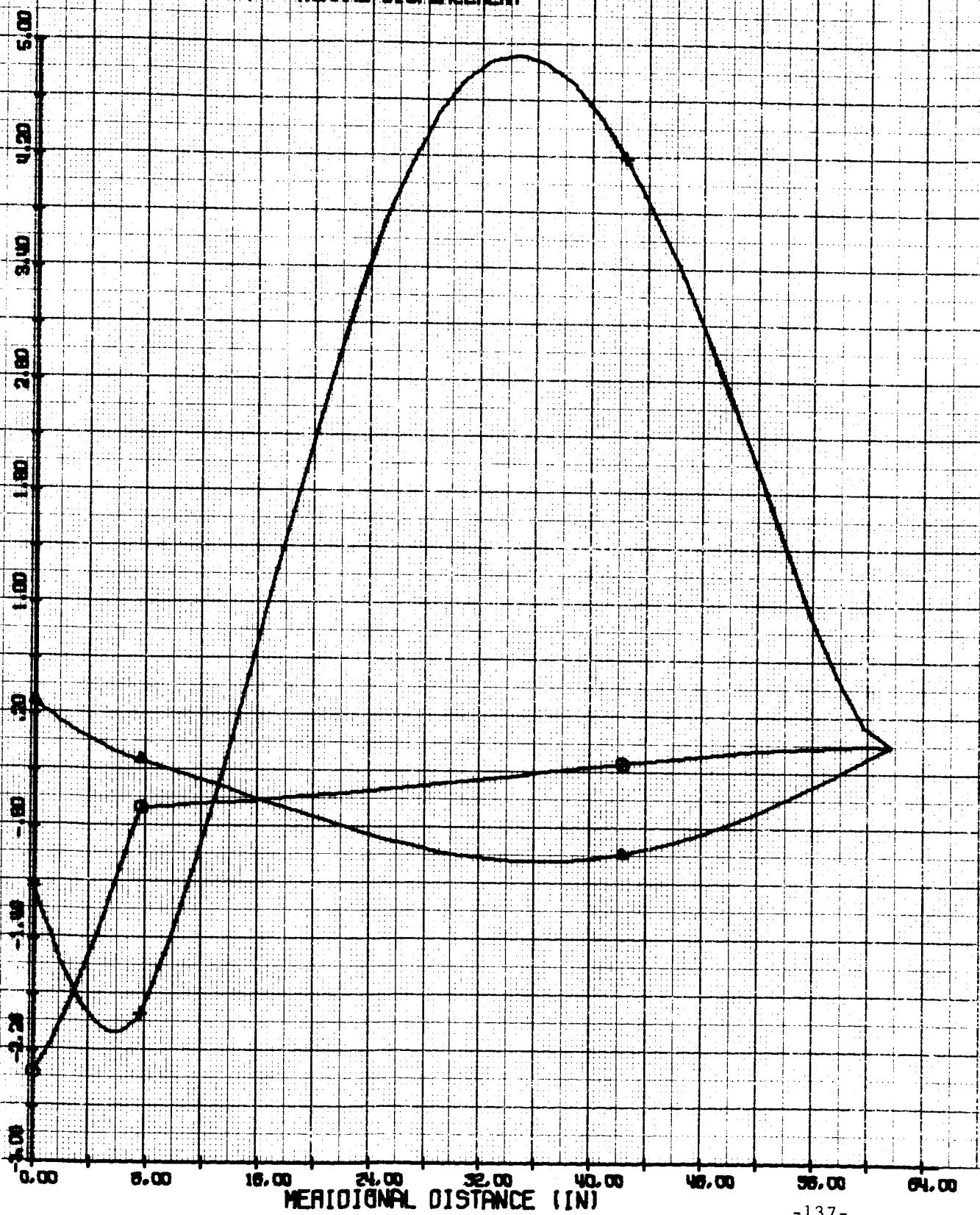


FIGURE 43c

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERMOLD. OMEGA 3=83.60 CPS (N=2)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

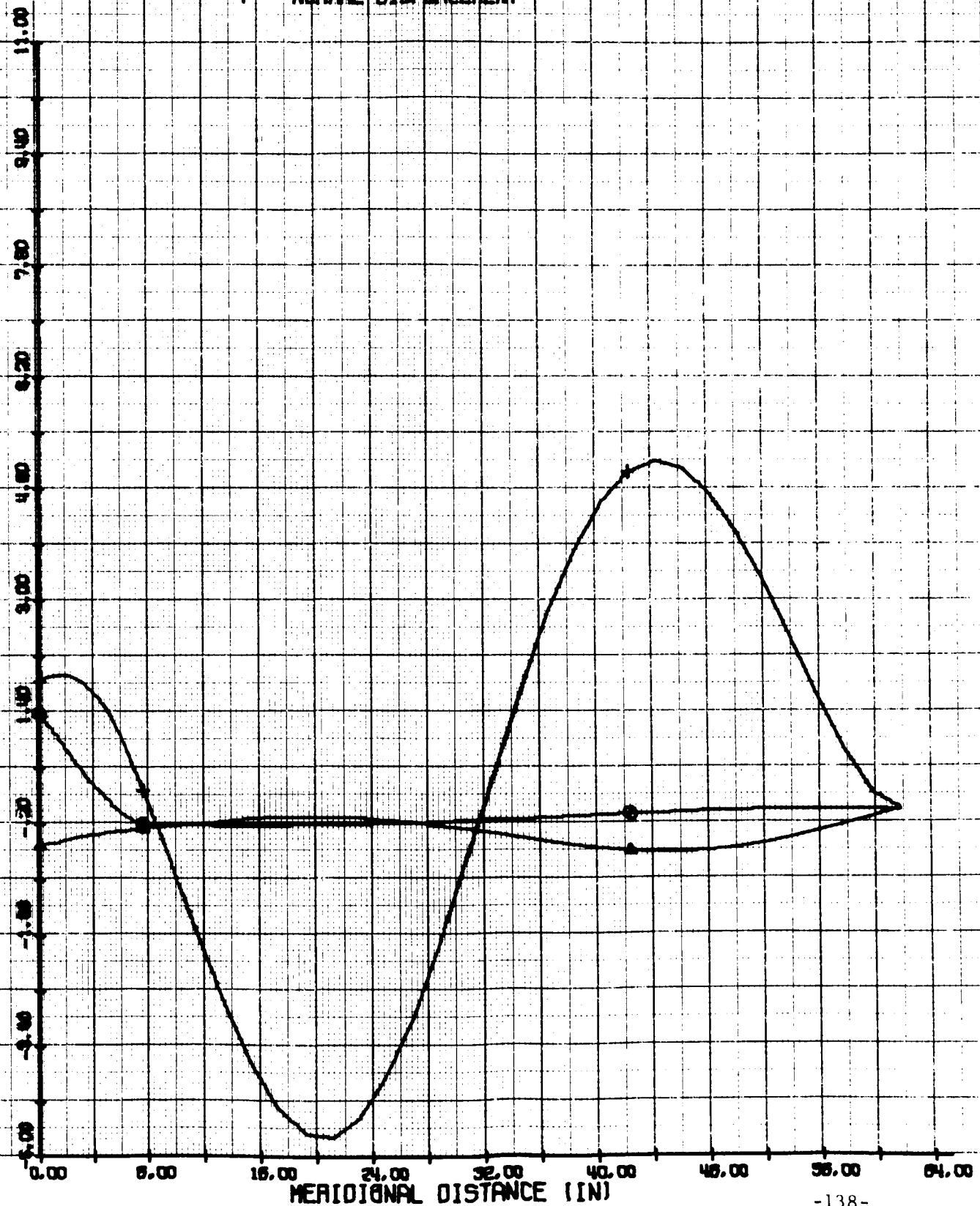


FIGURE 44a

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA 1-32.96 CPS (N=3)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

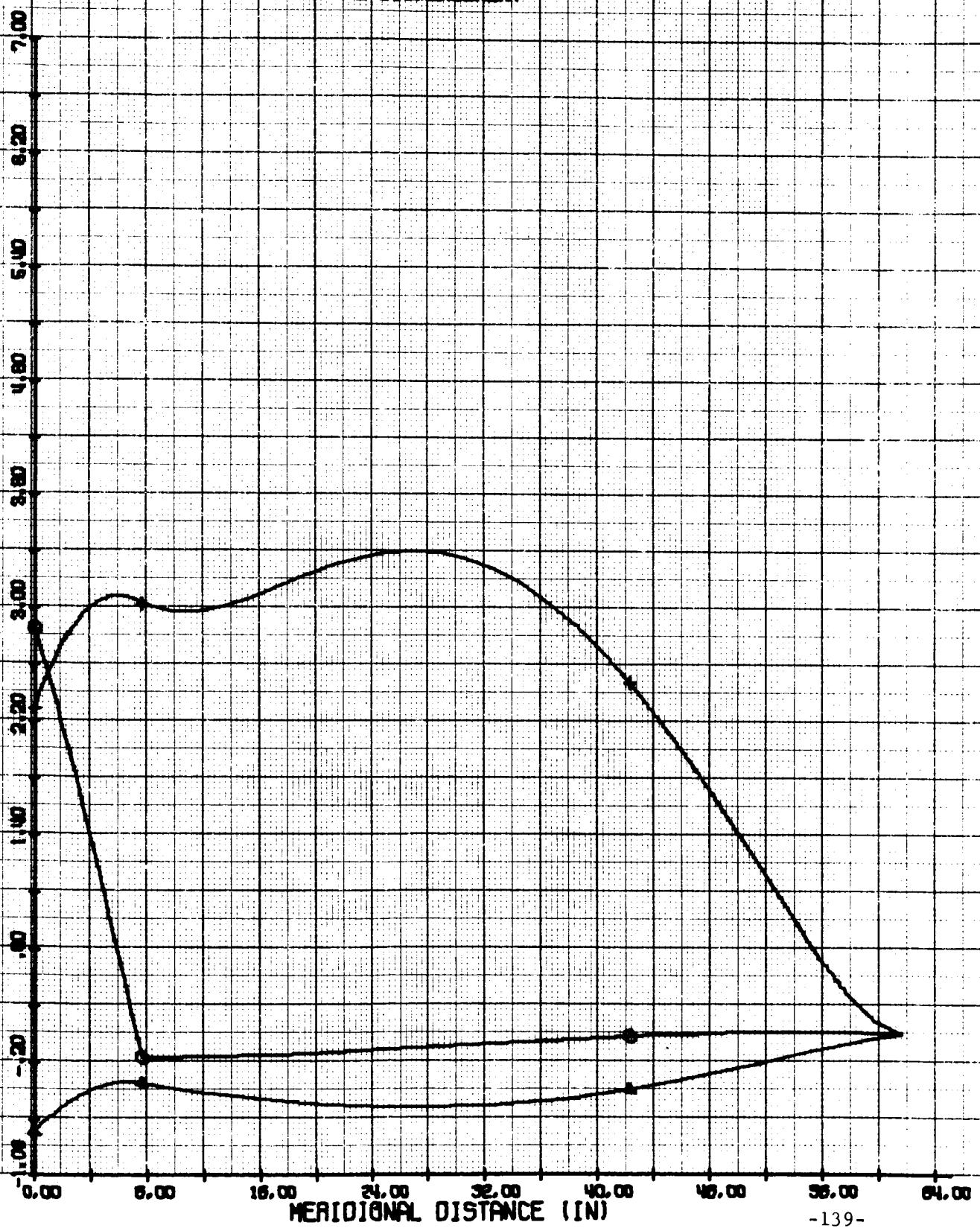


FIGURE 44b

VIBRATION MODE DISPLACEMENTS
CASE II. CAPSULE SNELL OVERHANG. OMENR 2-44.80 CPS (N=3)

- MERIDIONAL DISPLACEMENT
- △ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

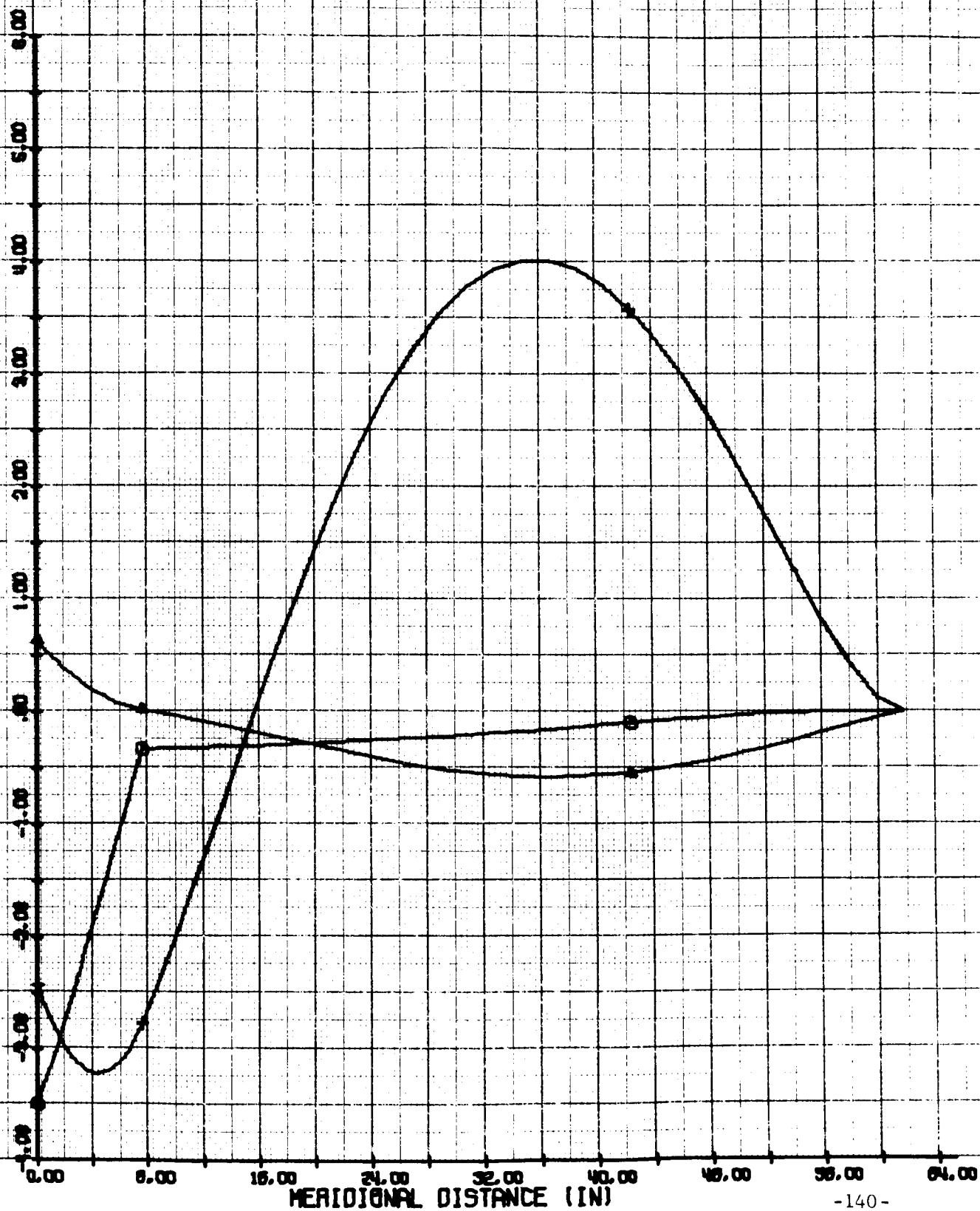


FIGURE 44c

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA 3-19.54 CPS (N=3)

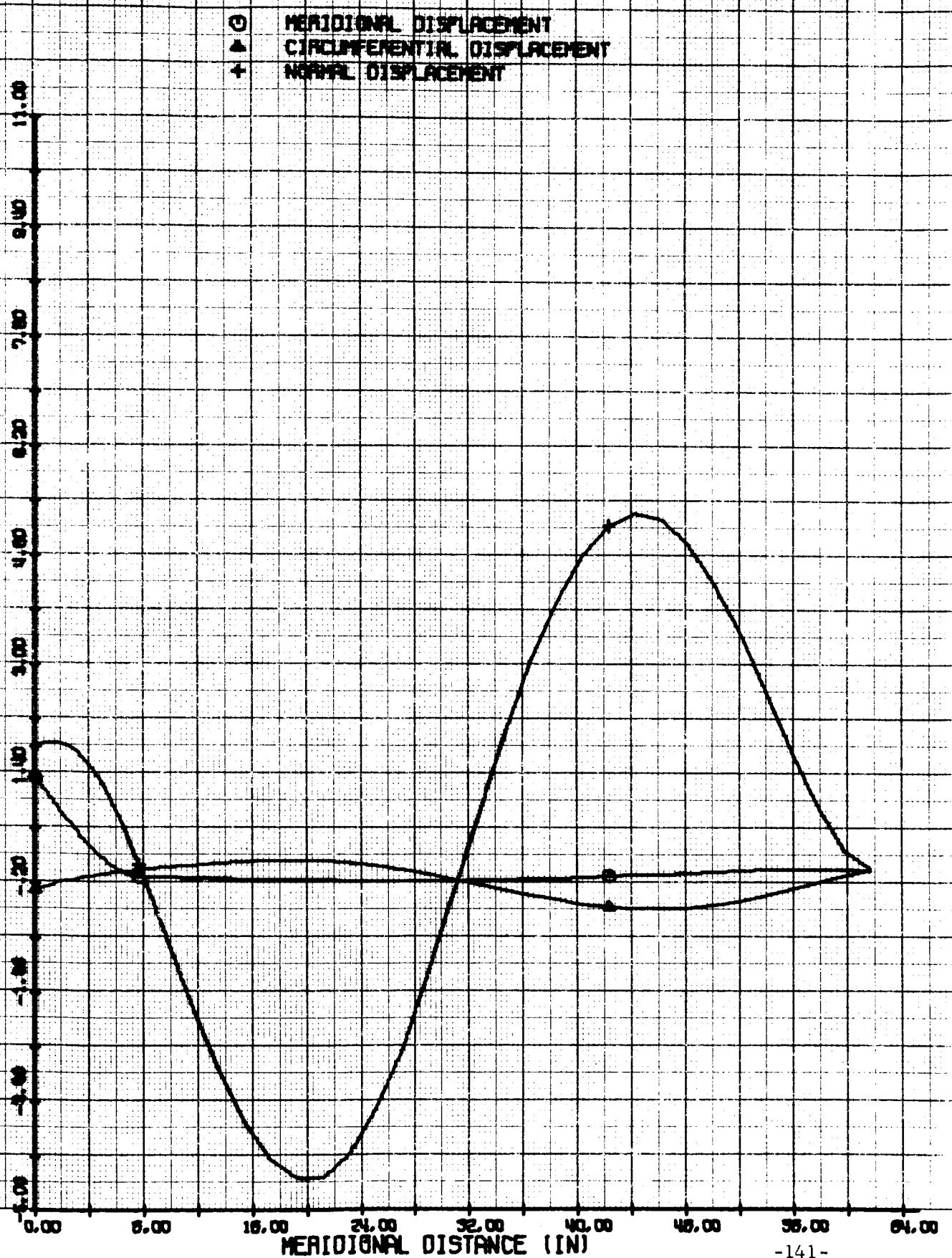


FIGURE 45a

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA 1=38.01 CPS (N=4)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

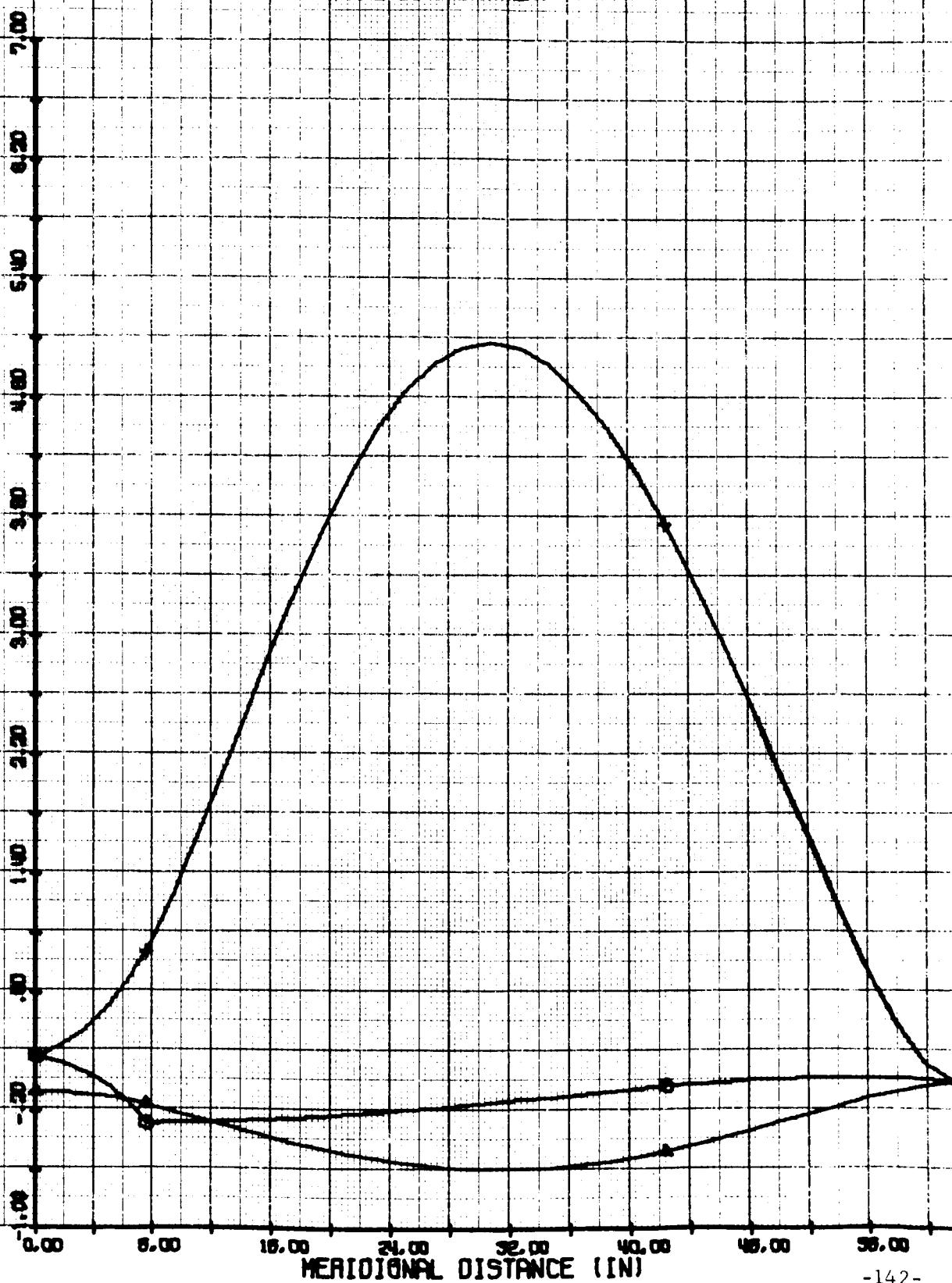


FIGURE 45b

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA = 71.53 CPS (N=4)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

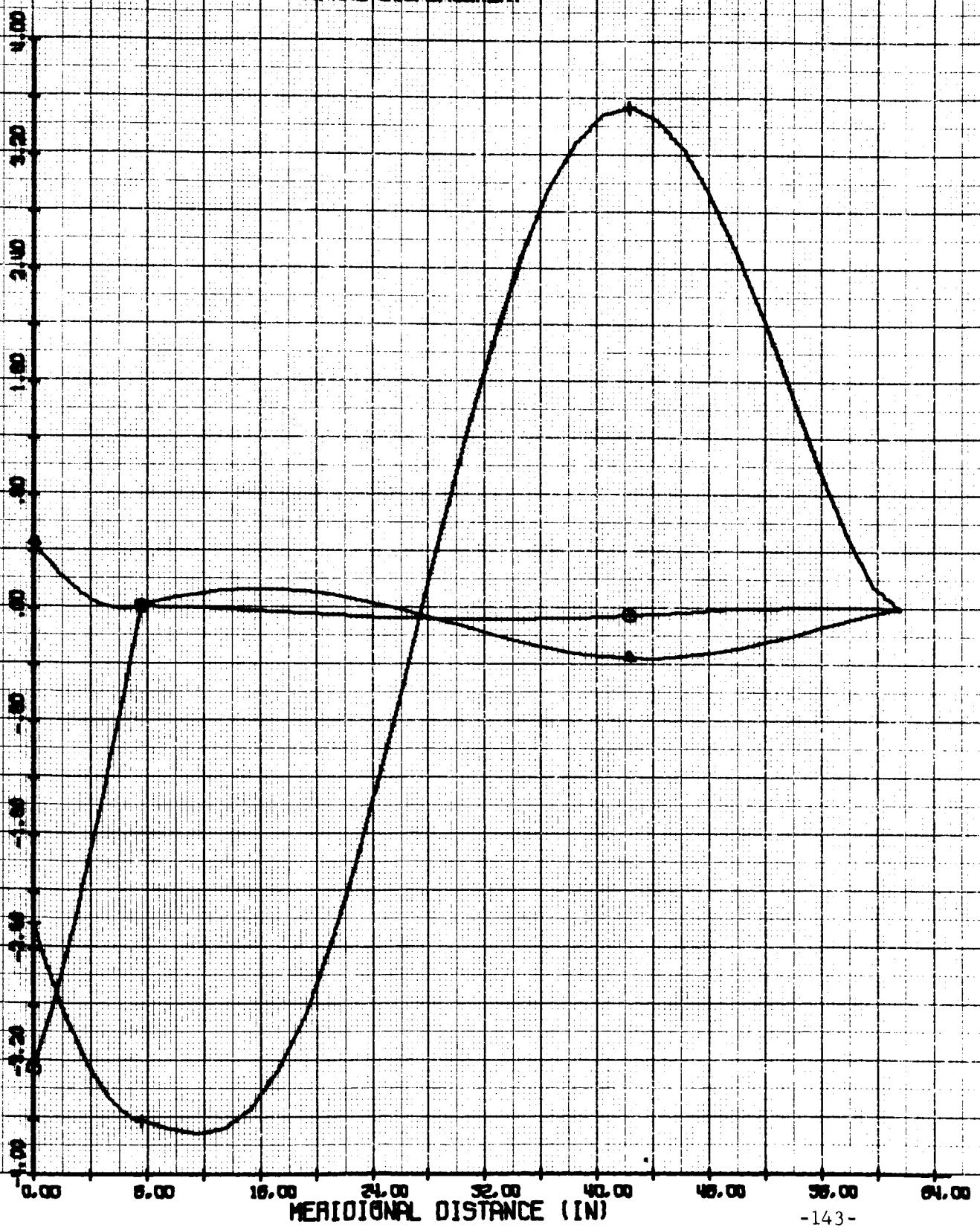


FIGURE 45c

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA 3=84.30 CPS (IN=4)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

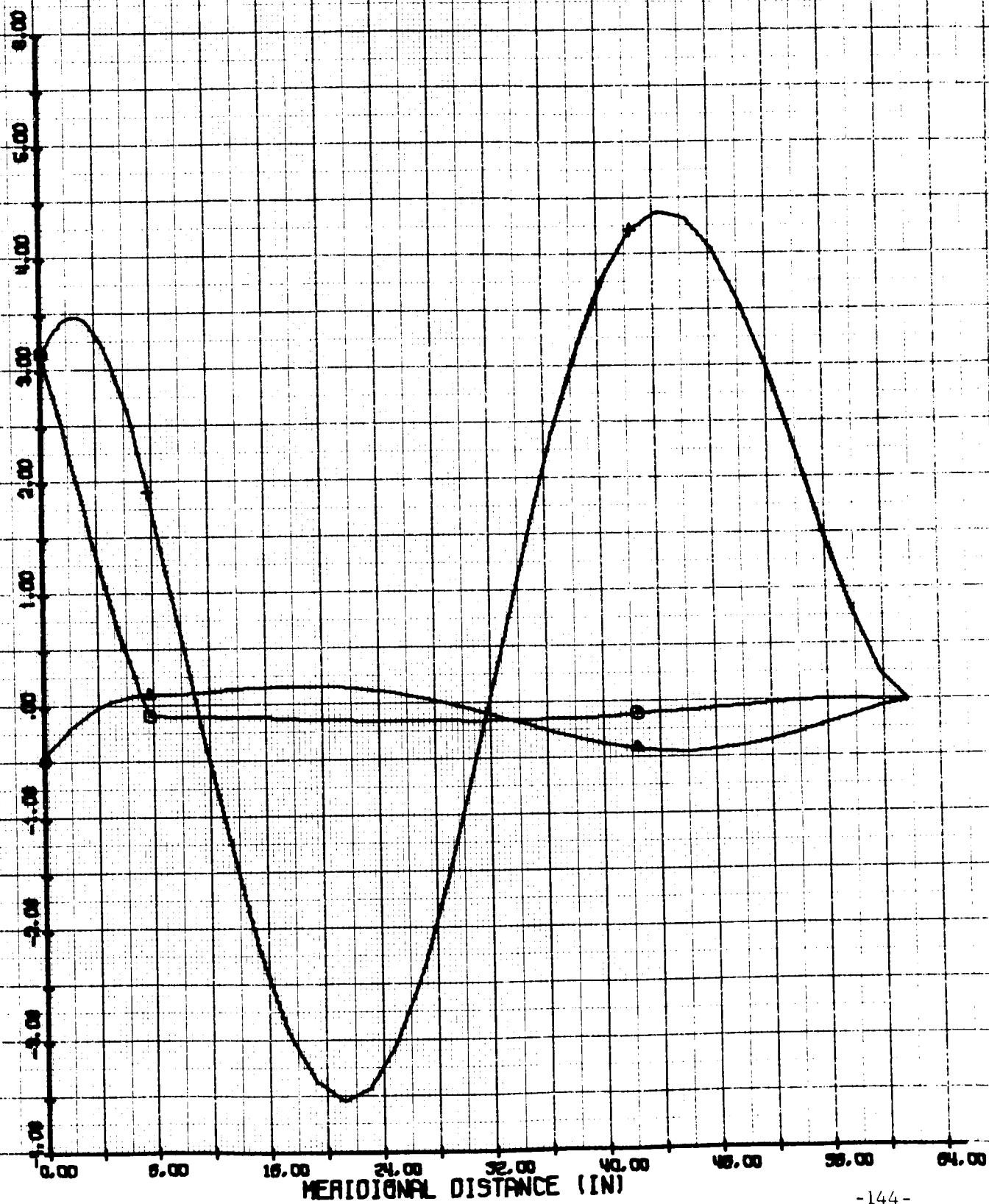


FIGURE 46a

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERWING. OMEGA 1=43.75 CPS (N=5)

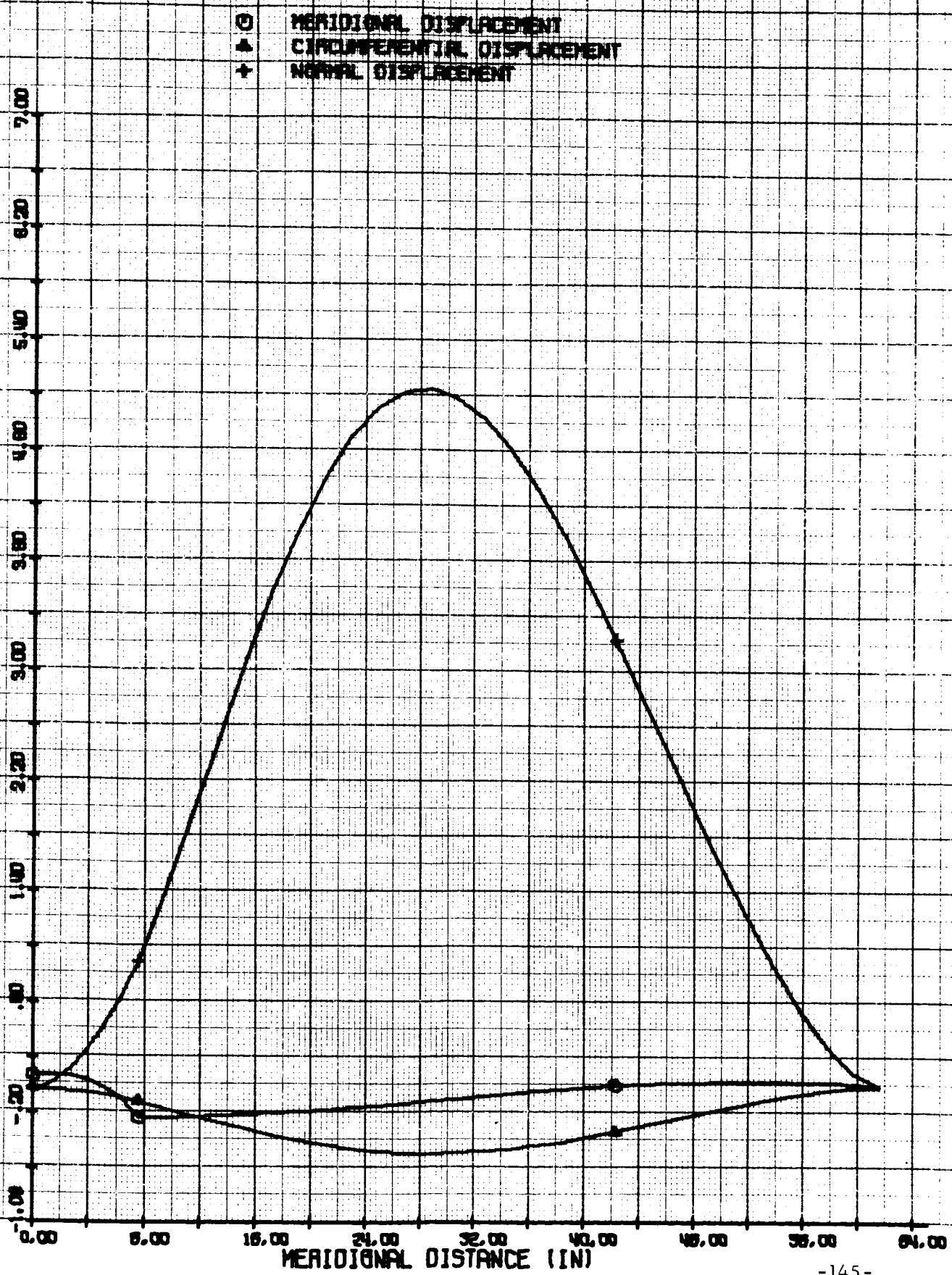


FIGURE 46b

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA 2=83.69 CPS (N=5)

- MERIDIONAL DISPLACEMENT
- △ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

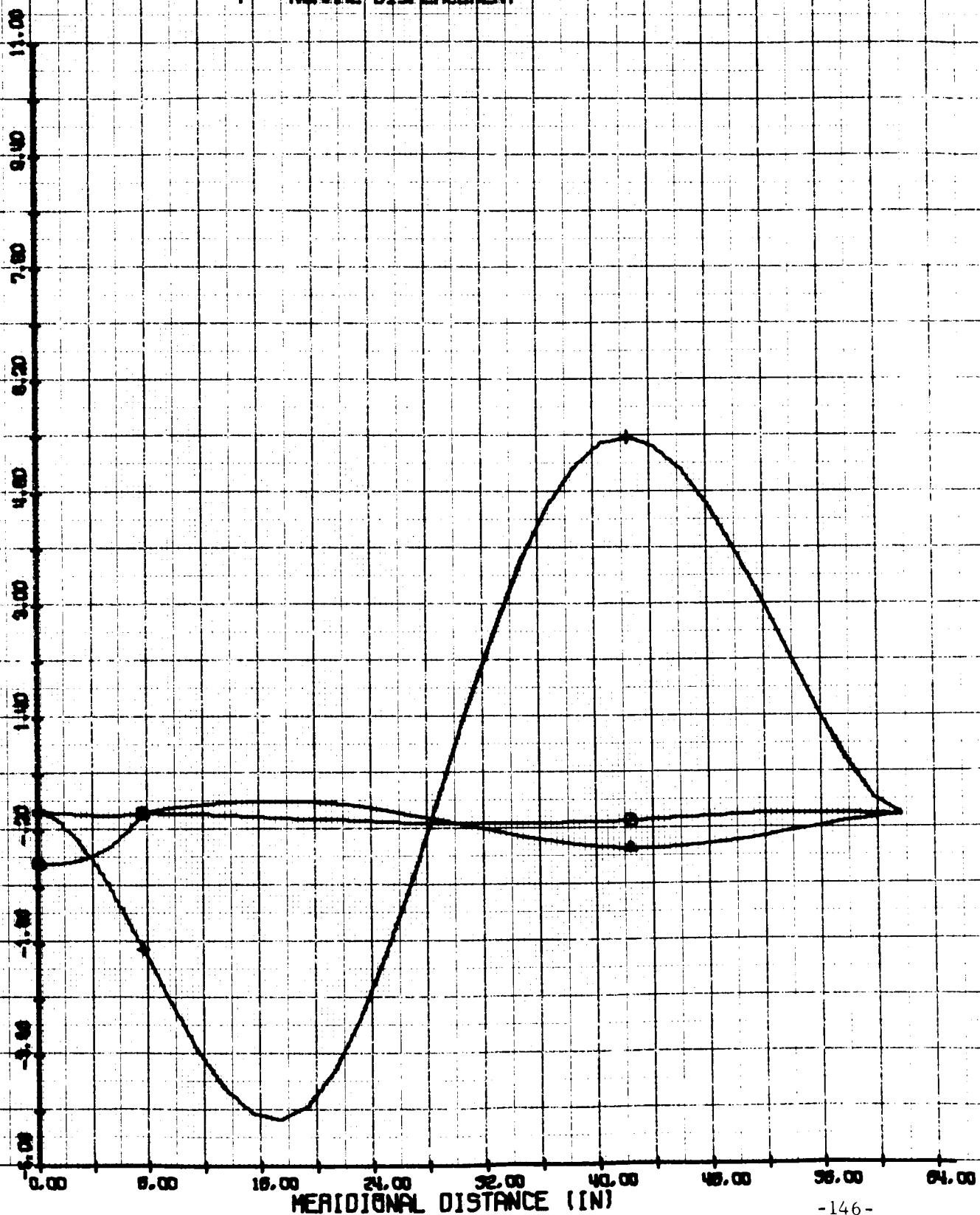


FIGURE 46c

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA 3=116.35 CPS (N=5)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

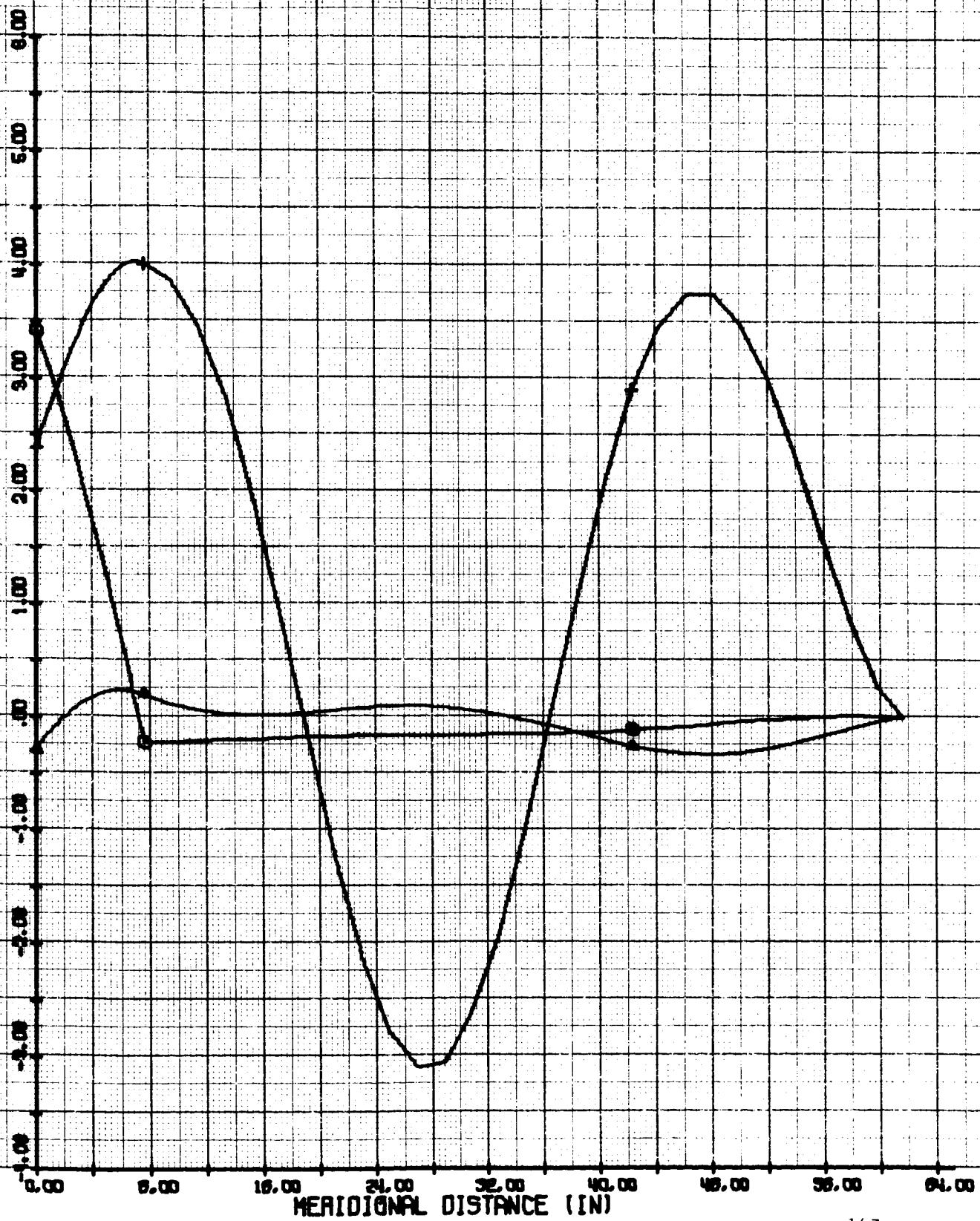


FIGURE 47a

VIBRATION MODE DISPLACEMENTS

CASE I. CAPSULE SHELL OVERRING. OMEGA 1 = 52.95 CPS (N=6)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

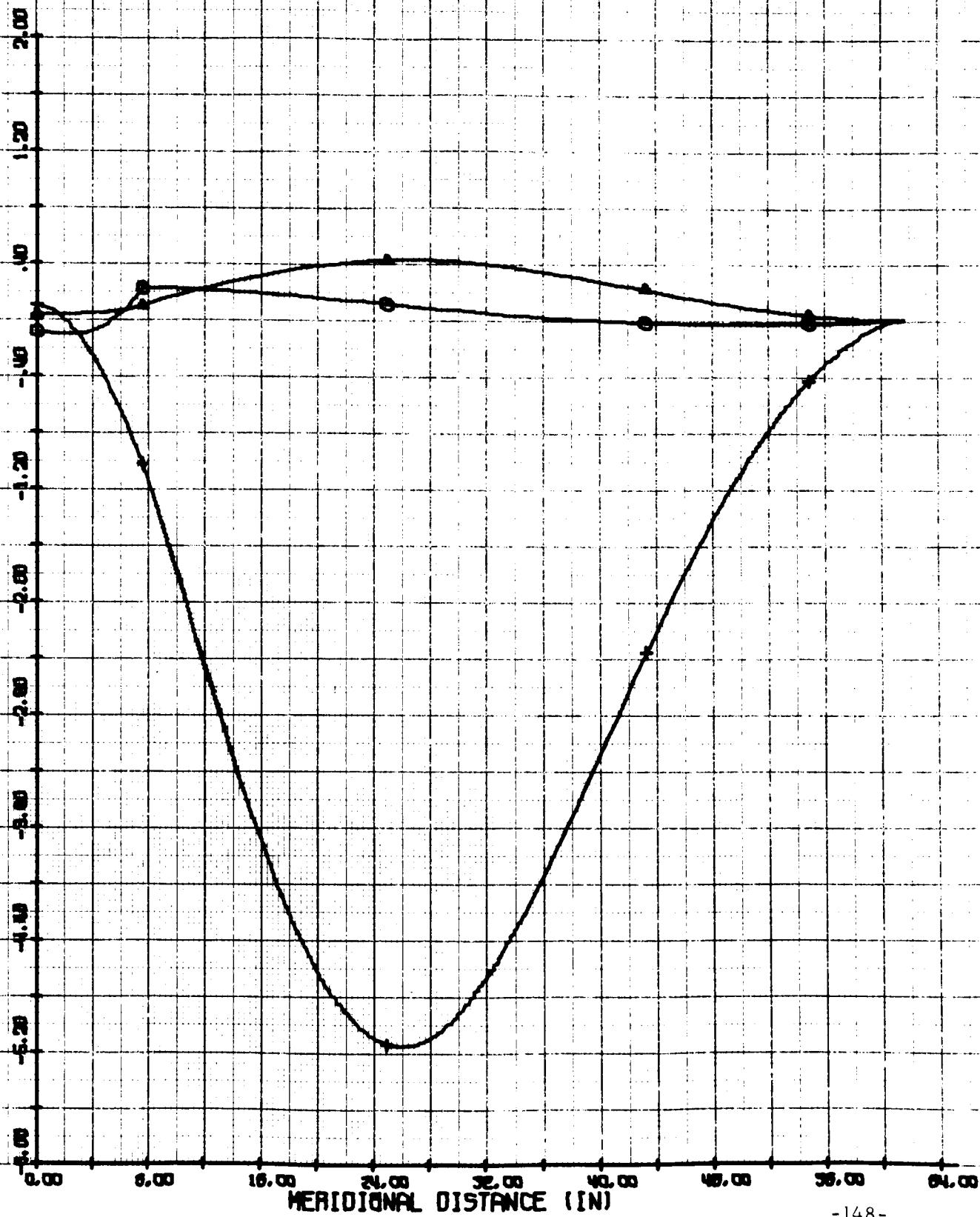


FIGURE 47b

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA 2 = 95.17 CPS (N=6)

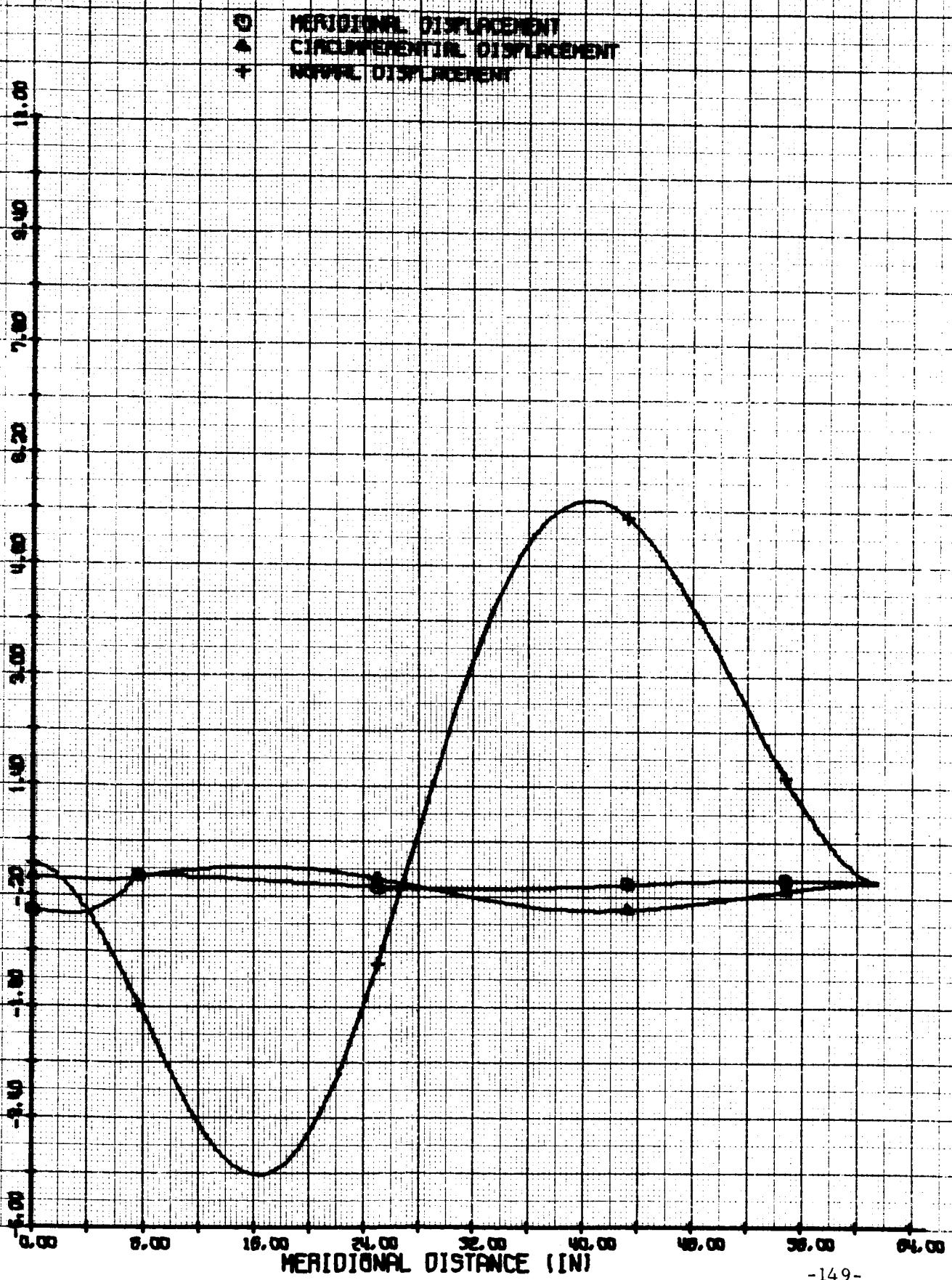


FIGURE 47c

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA 3 = 140.4 CPS (N=6)

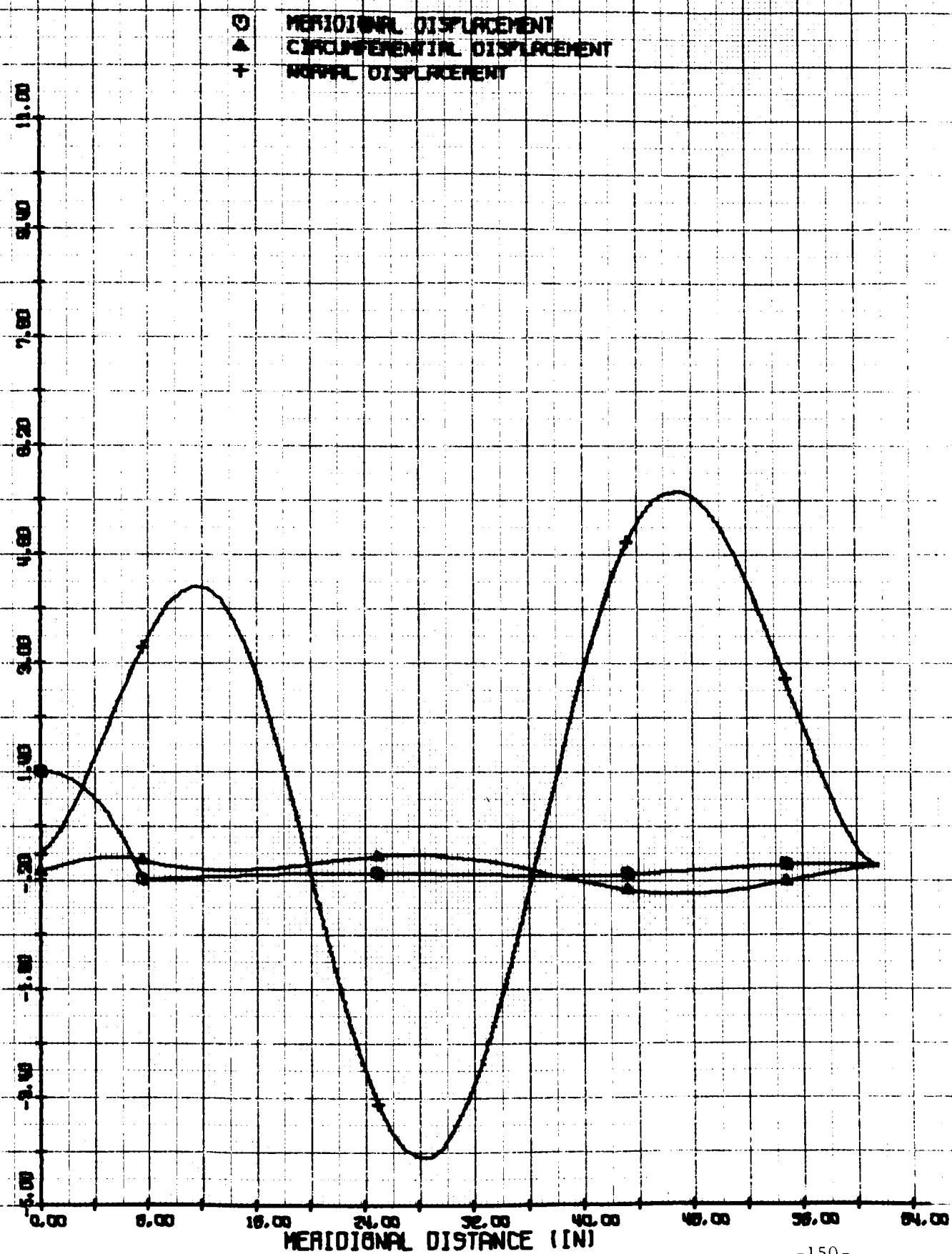


FIGURE 48a

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA 1 = 64.35 CPS (N=7)

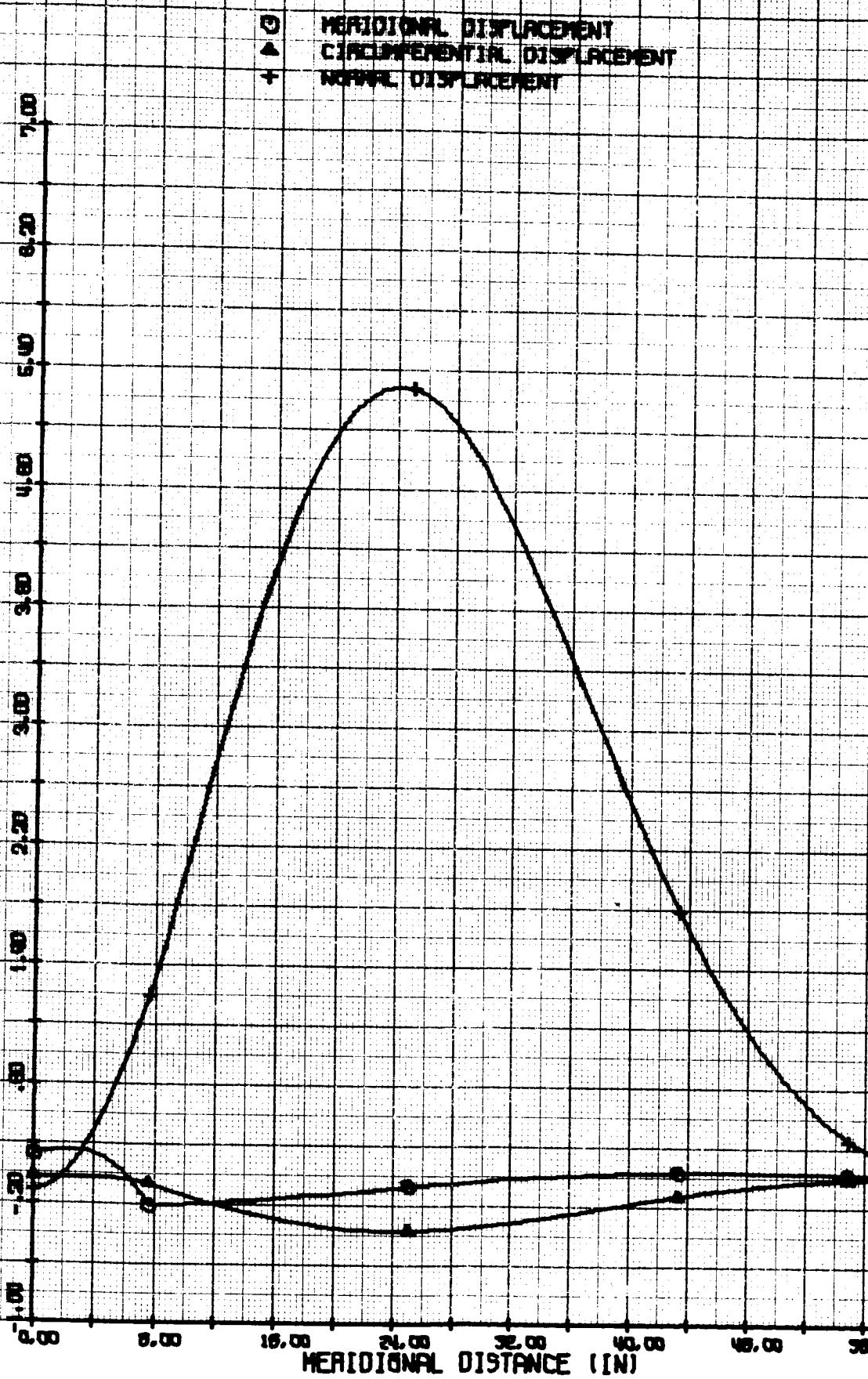


FIGURE 486

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA 2 = 109.9 CPS (N=7)

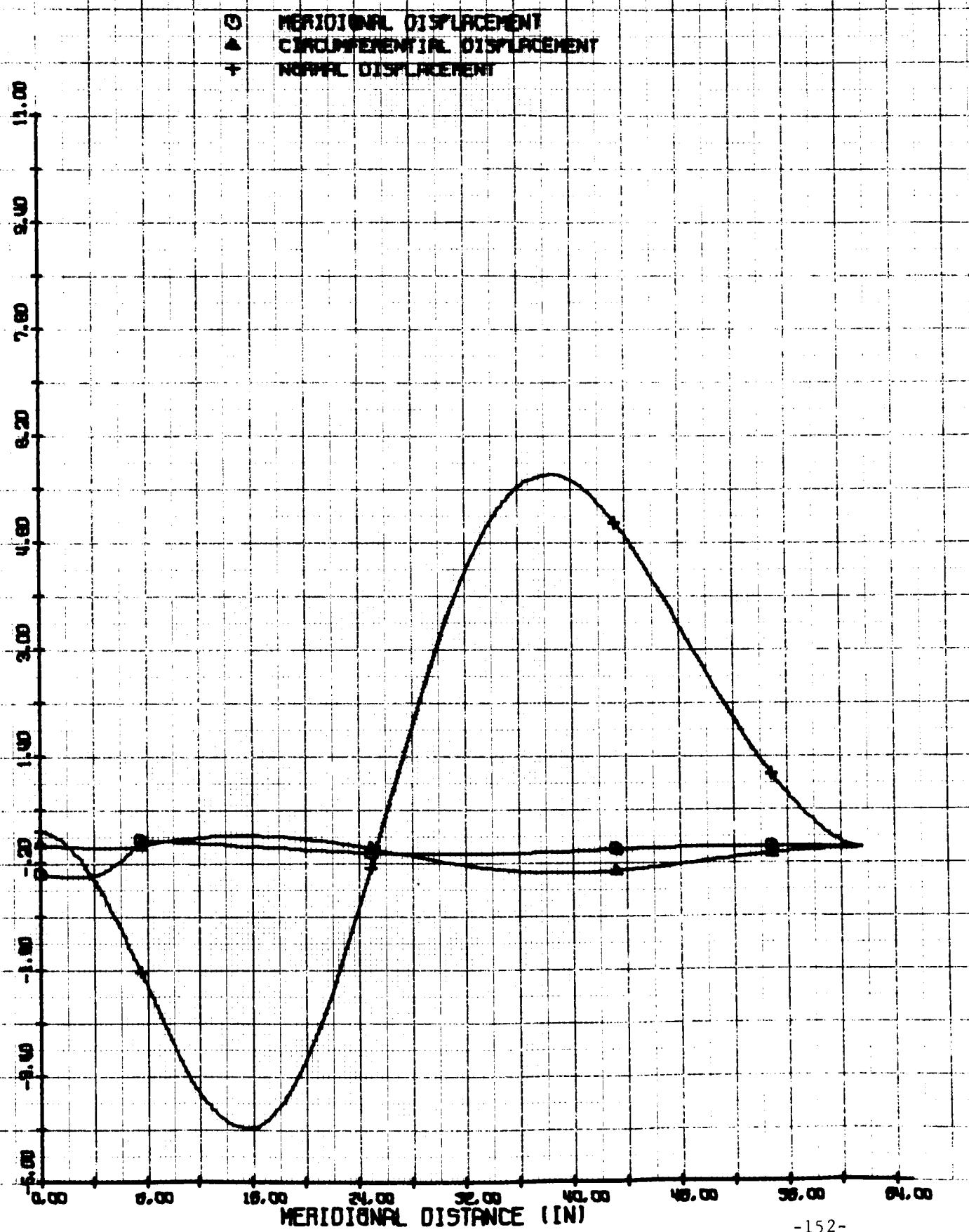


FIGURE 48c

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA 3 = 158.1 CPS (N=7)

○ MERIDIONAL DISPLACEMENT
△ CIRCUMFERENTIAL DISPLACEMENT
+ NORMAL DISPLACEMENT

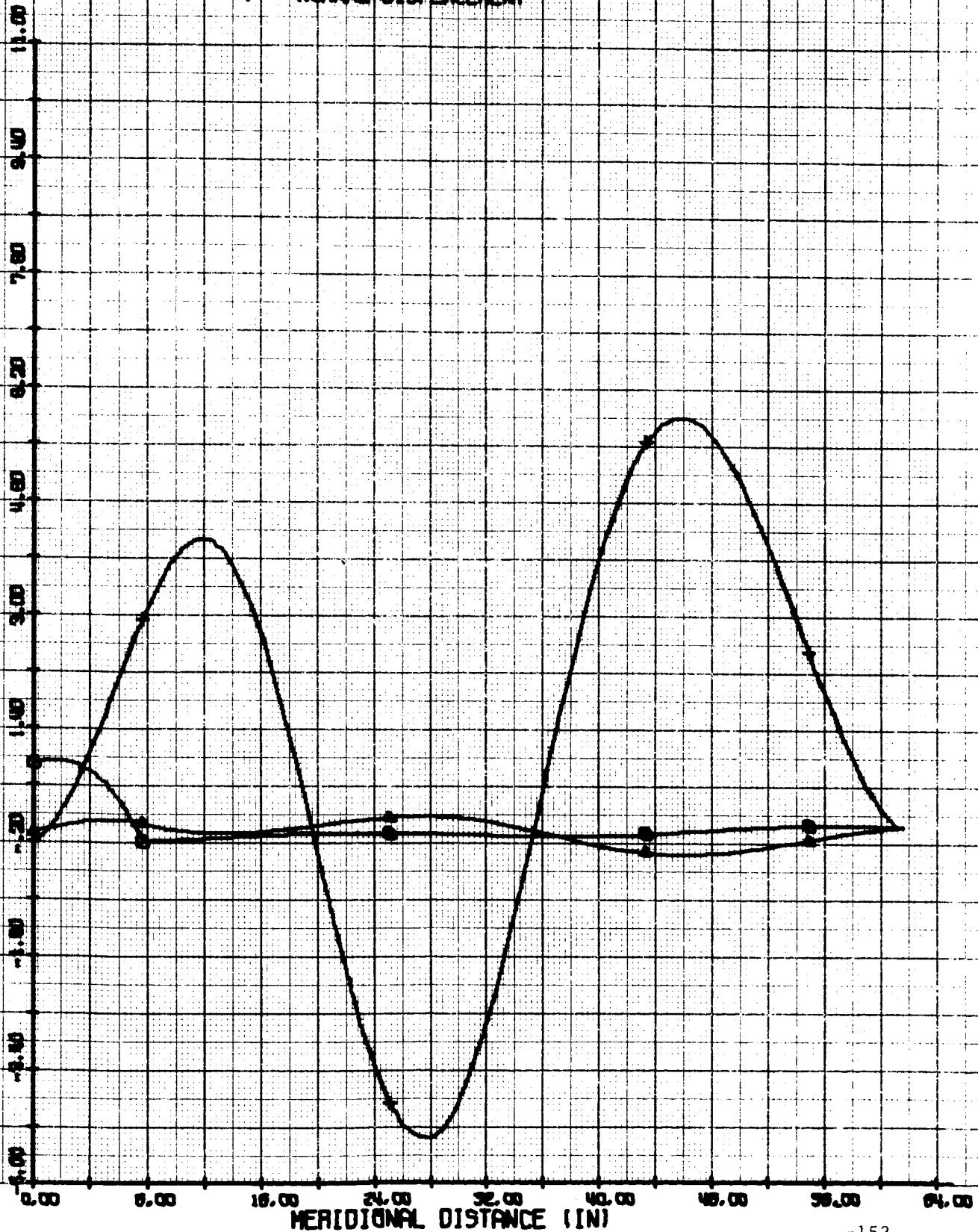


FIGURE 49a

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA 1 = 77.40 CPS (N=8)

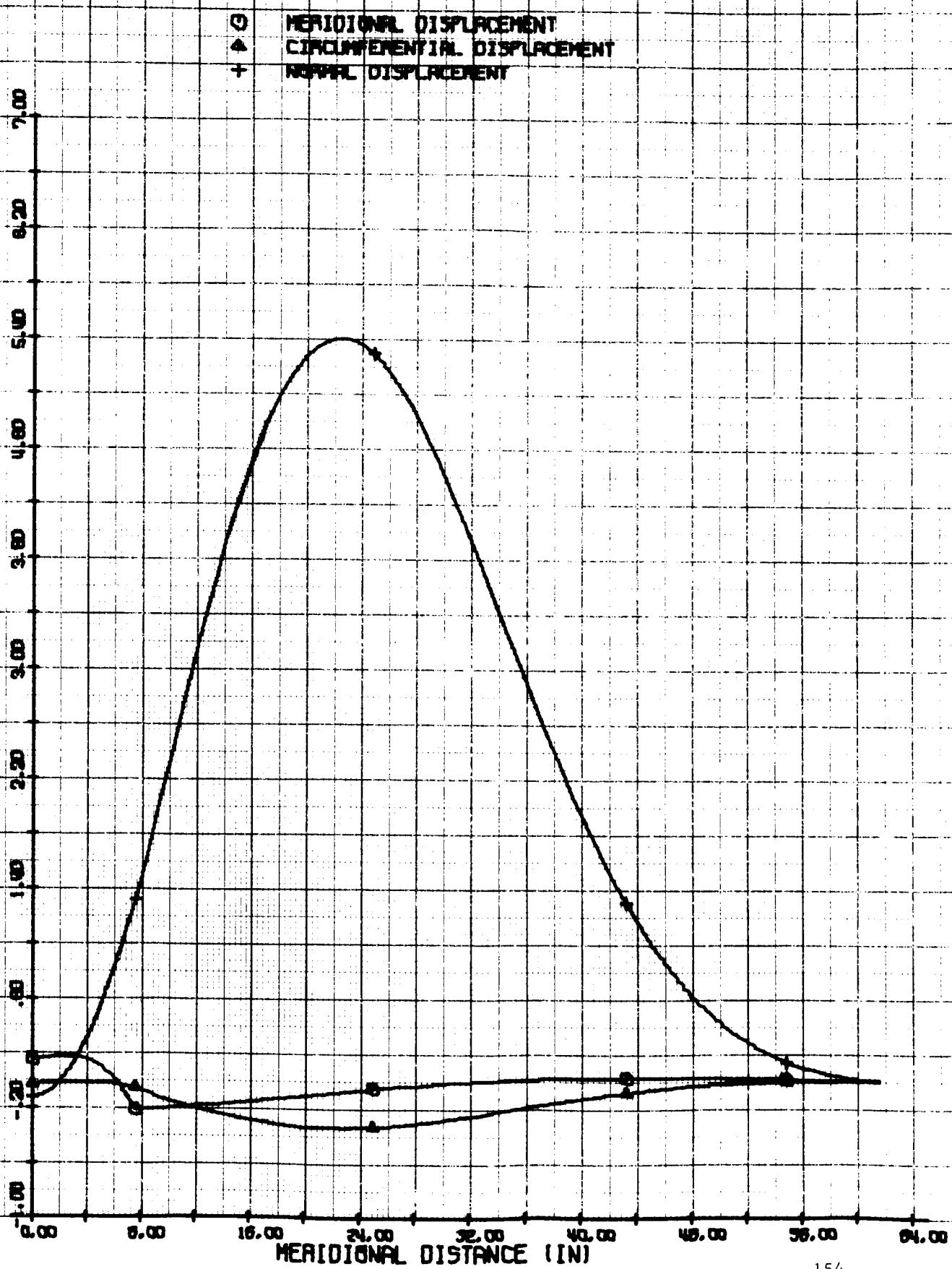


FIGURE 49b

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA 2 = 127.2 CPS (N=8)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

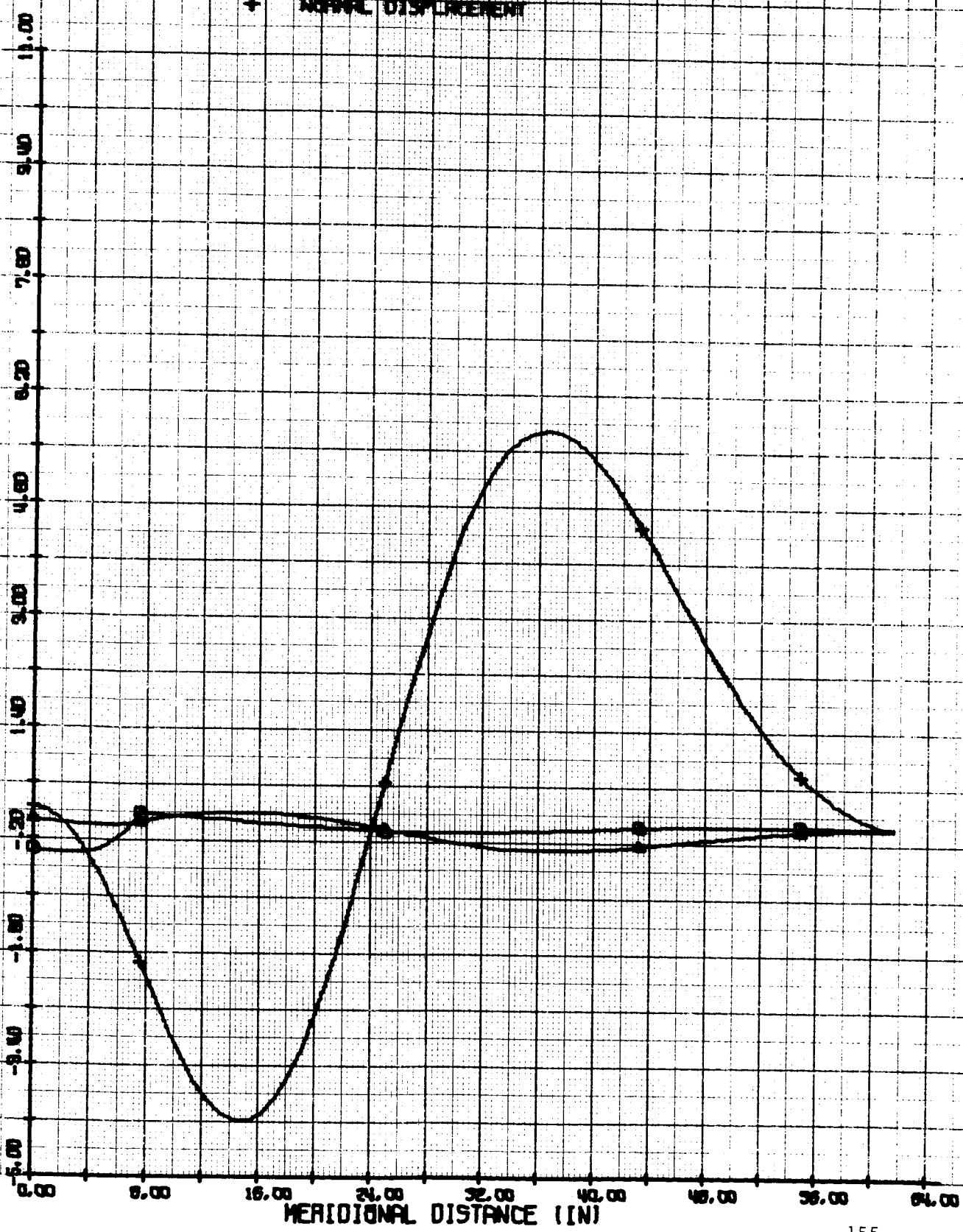


FIGURE 4Bc

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA 3 = 180.2 CPS (N=8)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

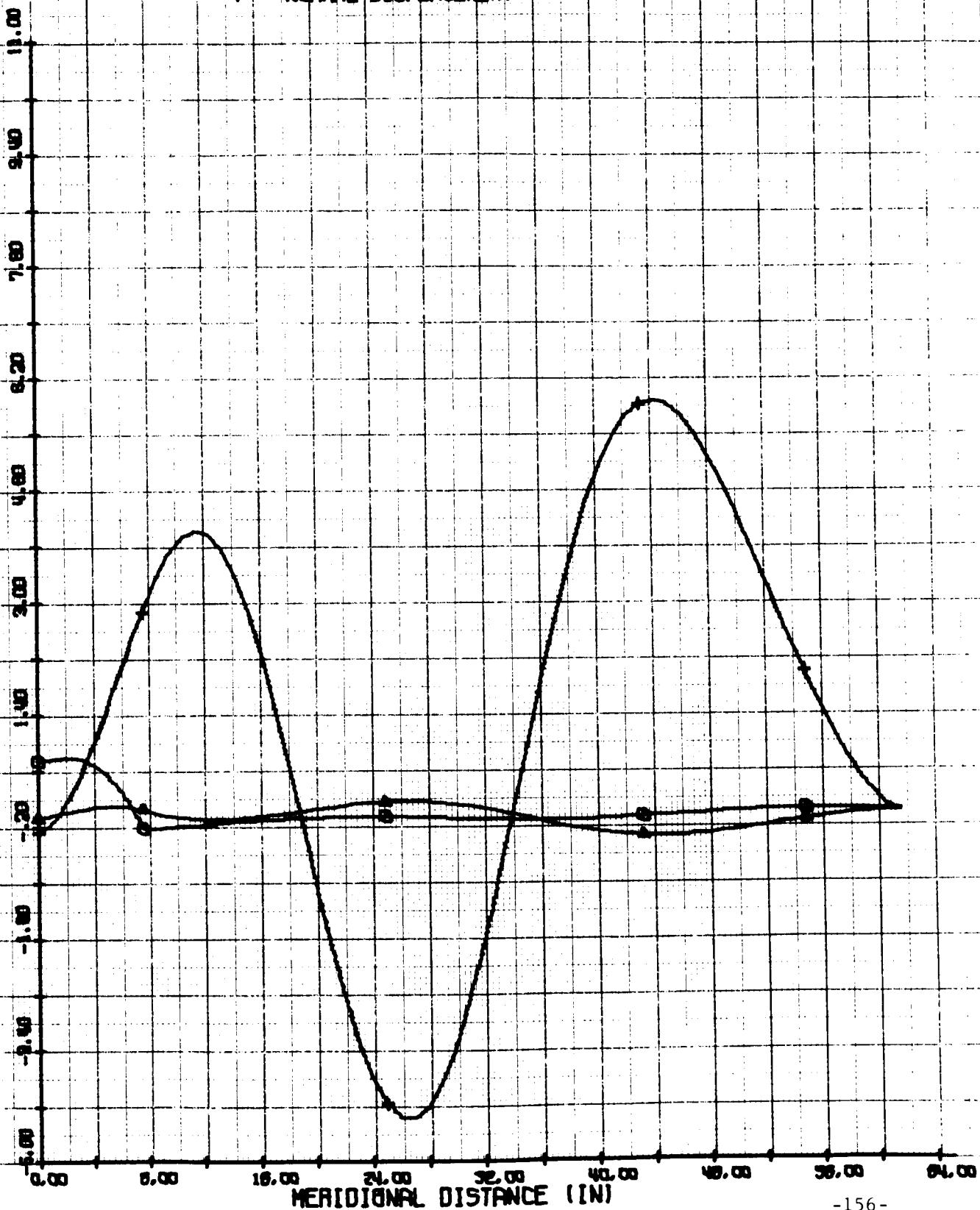


FIGURE 50a

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA 1 = 91.90 CPS (N=9)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

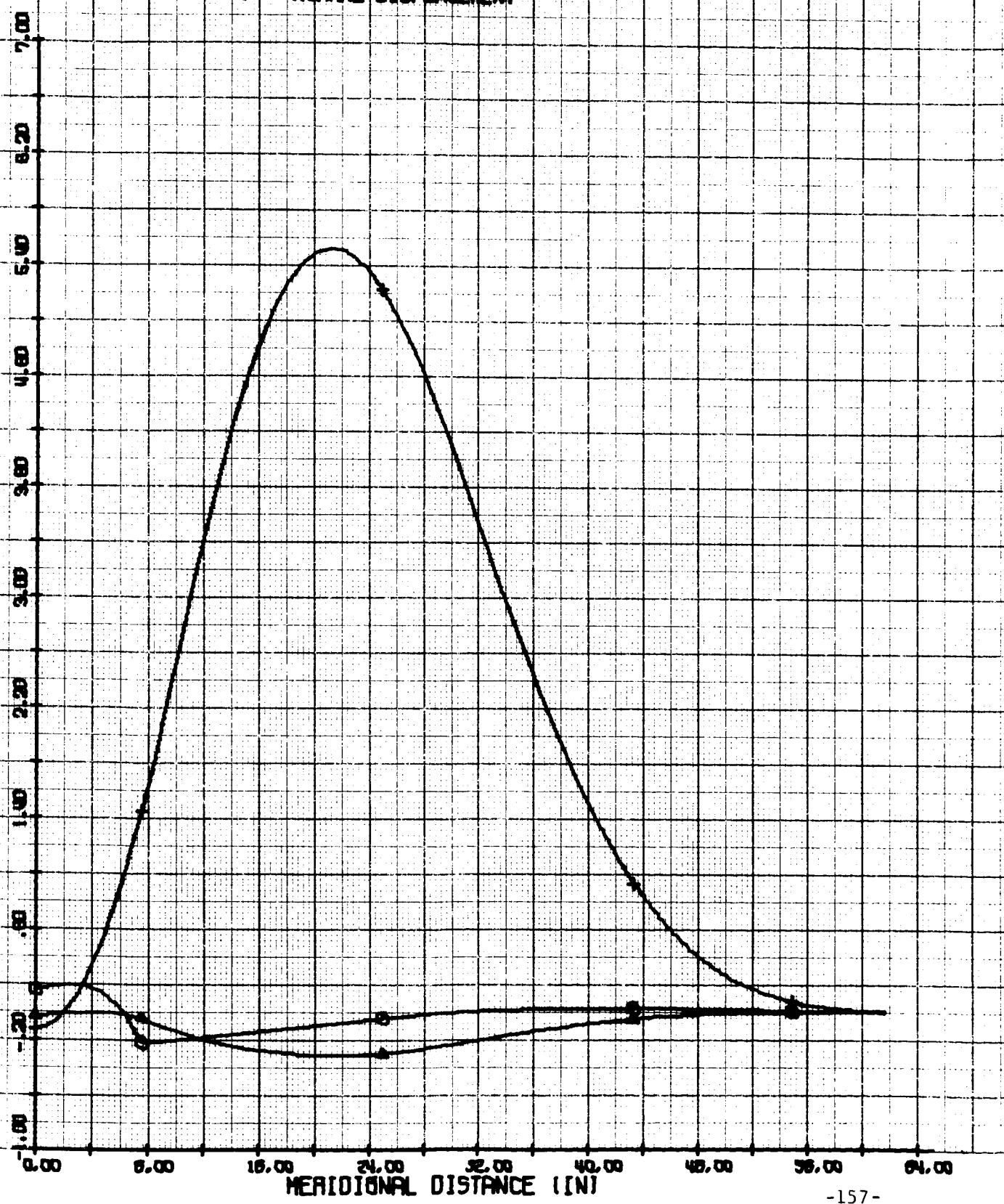


FIGURE 50b
VIBRATION MODE DISPLACEMENTS
CASE II. CAPSULE SHELL OVERHANG. OMEGA 2 = 146.4 CPS (IN-9)

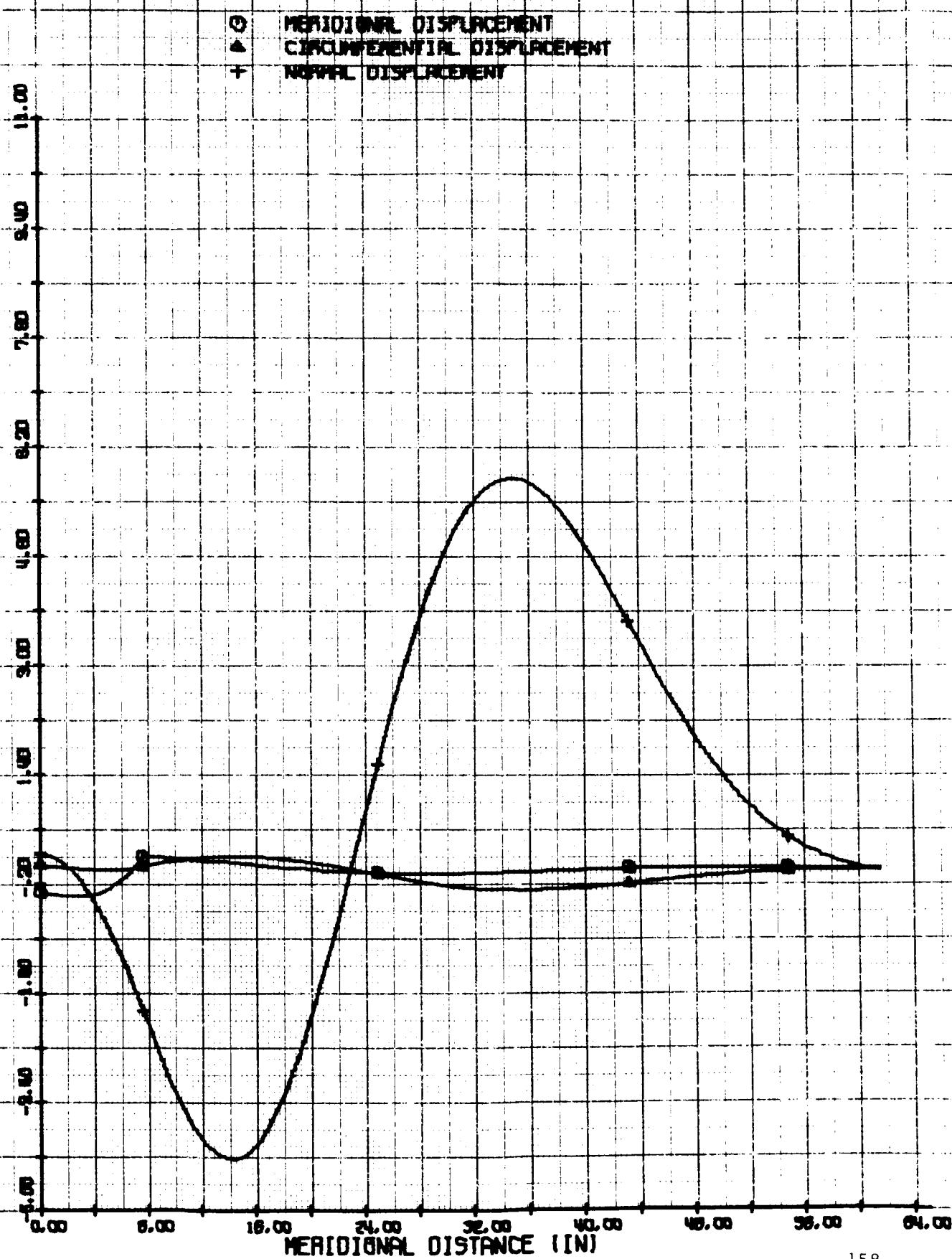


FIGURE 50c

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA 3 = 203.7 CPS (N=9)

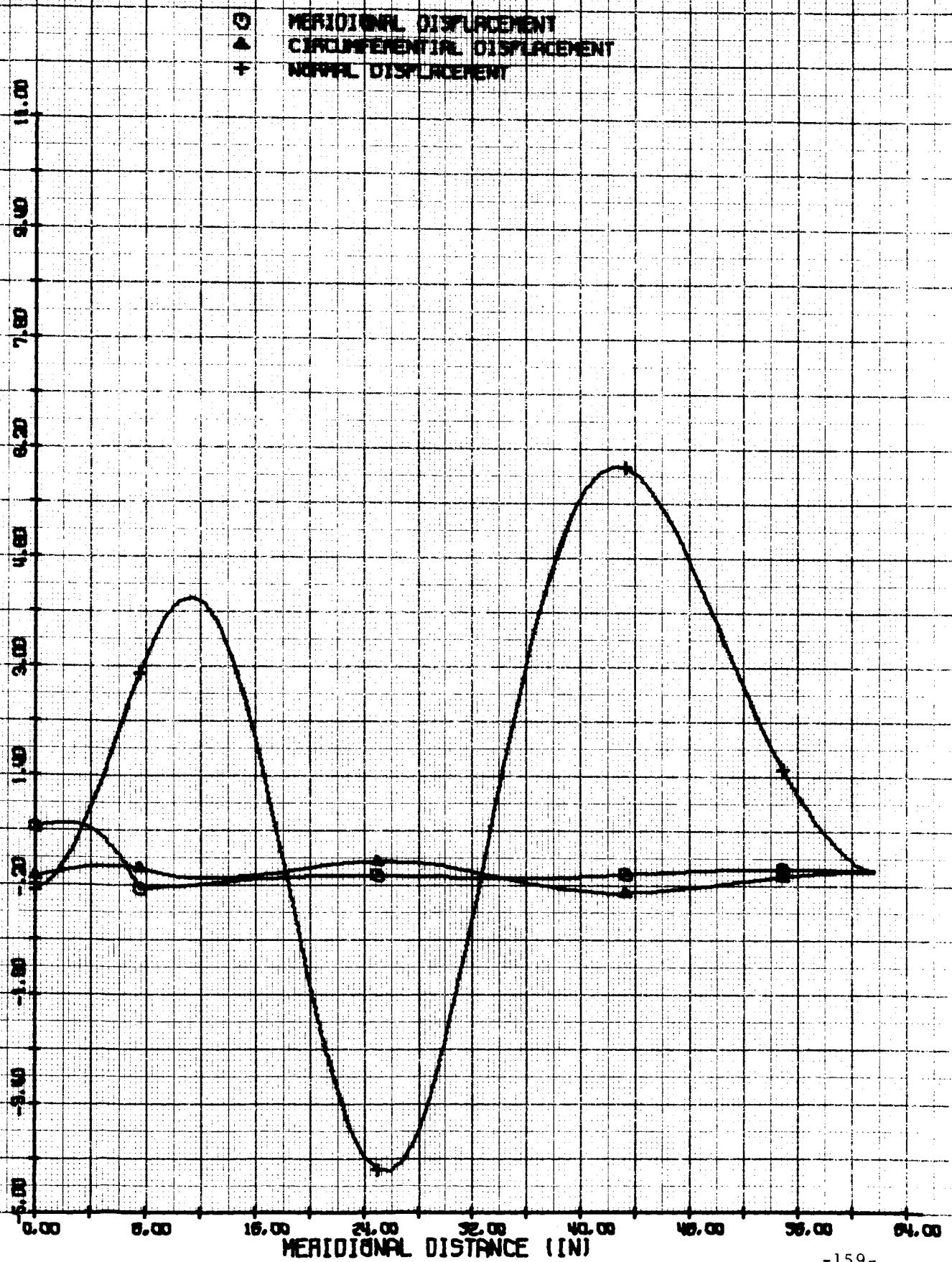


FIGURE 51a

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. OMEGA 1 = 107.7 CPS (N=10)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

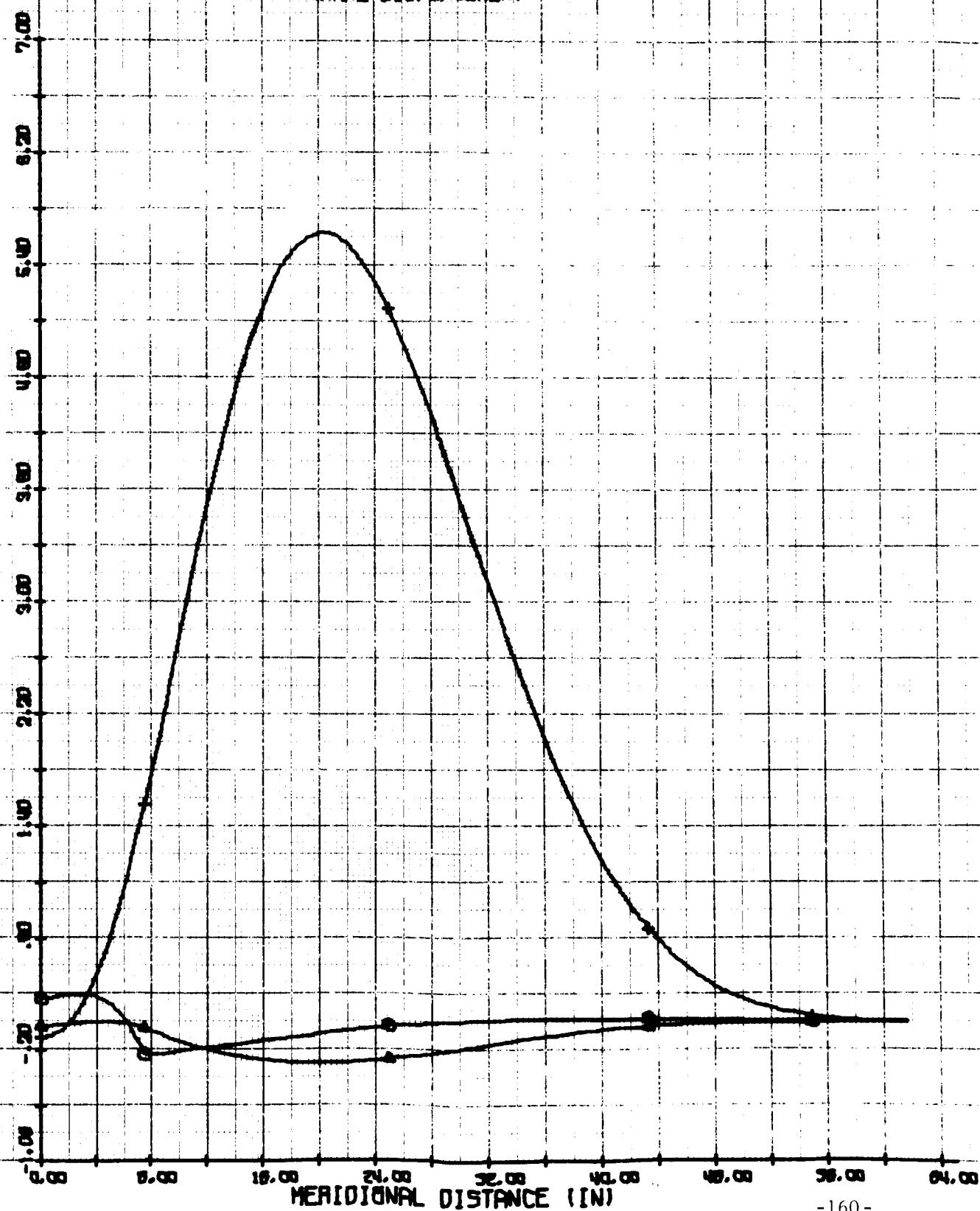


FIGURE 51b

VIBRATION MODE DISPLACEMENTS

CASE II. CAPSULE SHELL OVERHANG. $\Omega_{\text{EGR}} 2 = 167.1 \text{ CPS } (N=10)$

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

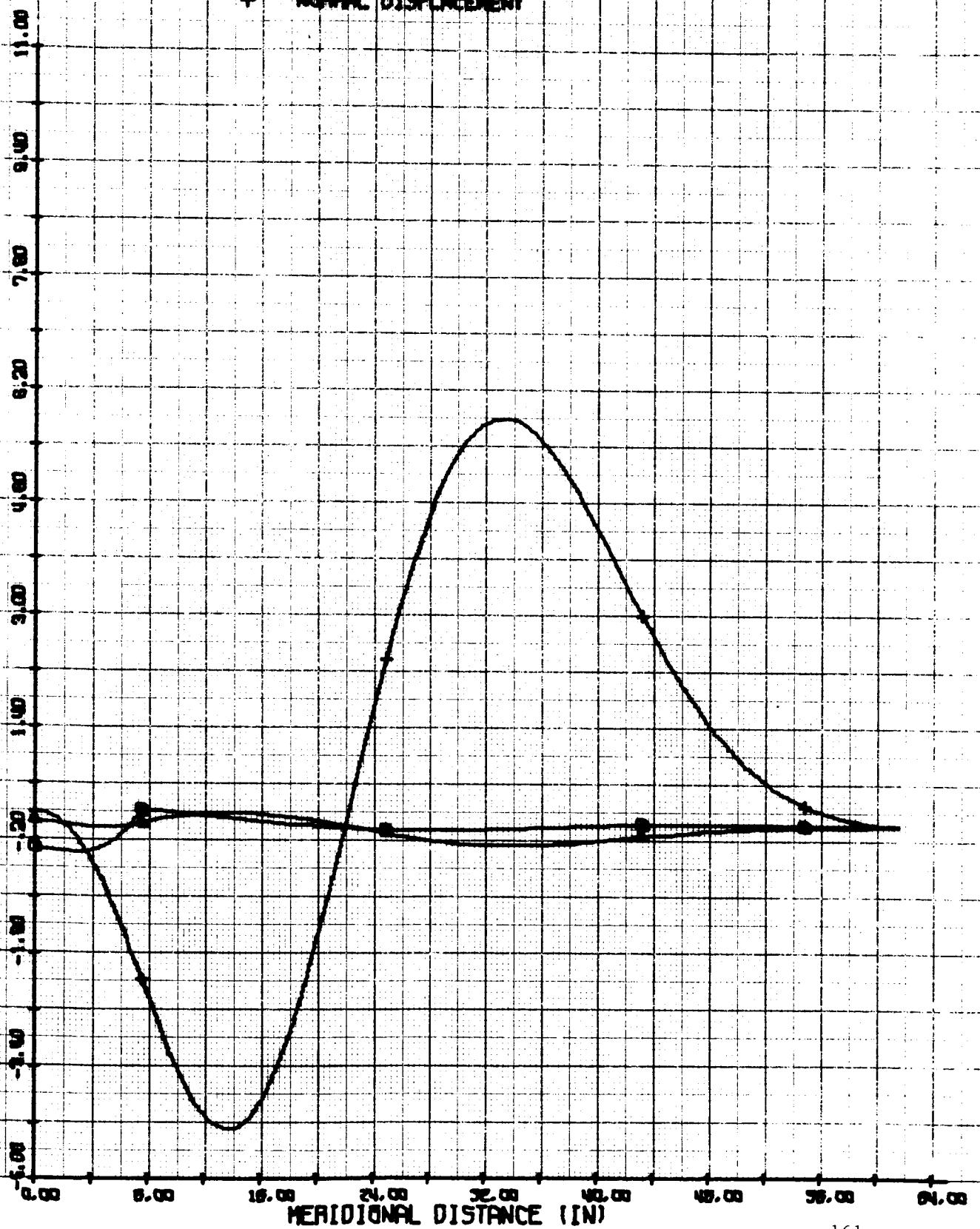


FIGURE 51c

VIBRATION MODE DISPLACEMENTS

CRSE II. CAPSULE SHELL OVERHANG. OMEGA 3 = 229.0 CPS (N=10)

- MERIDIONAL DISPLACEMENT
- ▲ CIRCUMFERENTIAL DISPLACEMENT
- + NORMAL DISPLACEMENT

